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VOLUME 51 DECEMBER 1, 1940 NUMBER 12, PART 2

CONTENTS

PAGES

Abstracts of The Geological Society of America

December meeting at Austin **1919–1954**

Cordilleran Section meeting at Los Angeles in April **1955–1966**

Abstracts of the Paleontological Society

December meeting at Austin **1967–1980**

Pacific Coast Branch meeting at Los Angeles in April **1981–1988**

Abstracts of Section E, American Association for the Advancement of Science

December meeting at Philadelphia **1989–2014**

June meeting at Seattle **2015–2038**

Papers presented at Columbus (1939) meeting but not previously published **2039–2042**

(For abstracts of Mineralogical Society of America, *see* Mineralogical Society of America program.)

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ABSTRACTS OF THE GEOLOGICAL SOCIETY OF AMERICA

DECEMBER MEETING AT AUSTIN

ANDALUSITE IN CALIFORNIAN EOCENE SEDIMENTS

BY VICTOR T. ALLEN

Californian Chico Cretaceous sandstones near Folsom and Pentz and at the type locality on Chico Creek lack pink andalusite. The overlying Eocene Ione sandstones and correlated auriferous gravels contain pink andalusite derived from the bedrock series of the Sierra Nevada. If these Cretaceous and Eocene sediments were both derived from the same source, it appears that contact aureoles around Sierran intrusions with a grade of metamorphism sufficiently high to contain andalusite were not exposed by erosion until Eocene time. Under the Great Valley at several localities a similar limitation of andalusite to the Eocene and younger sediments has been found. It is suggested that careful watch be kept by all investigators to check the possibility of using andalusite to separate Cretaceous from Eocene sediments in California. (Geological Society project.)

JOINT PATTERNS IN HIGHLY FOLDED AND CRYSTALLINE ROCKS OF THE NORTHERN NEW JERSEY HIGHLANDS AND THEIR RELATION TO APPALACHIAN OROGENY

BY ALFRED N. APPLEBY*

Pre-Cambrian rocks predominate in the Highlands of northern New Jersey. Associated with them are Paleozoic formations, the youngest of which are Devonian. All are highly folded and metamorphosed. The mantle is largely resultant from Pleistocene glaciation. The rocks are well jointed. Most are shear joints caused by compressive stresses.

The observations were made in an area of approximately 200 square miles, between Dover and the New York State line and between Hamburg and Pompton Lakes. For purposes of comparison, some Triassic rocks to the east of this area were examined.

Readings were taken with a Brunton compass at 259 outcrops. More than 800 strikes and dips of joint systems were recorded. The figures were then tabulated, and their regional distribution and dispositions analyzed. Descriptive geometry was employed to determine the angles between sets of intersecting major joints and to determine the directions of application of stress. A mathematical investigation, suggested by analysis of the tables, was undertaken.

The arrangement of force lines indicates that regional rather than local stresses caused the jointing. The patterns show that the jointing was not controlled by foliation or bedding planes and that the jointing now in evidence occurred later than the magmatic invasions and folding. The jointing is closely related to the Appalachian orogeny.

DISTRIBUTION AND ORIGIN OF TEKTITES

BY VIRGIL E. BARNES†

Tektites are naturally etched pebbles of acidic glass mostly black and lustrous in reflected light and bottle green, smoky, or brown in transmitted light. They are found in siliceous gravels of Miocene to Pleistocene age in Czechoslovakia, Australia,

* Introduced by Ernest R. Lilley.
† Introduced by E. H. Sellards.

Indo-China, Philippine Islands, Dutch East Indies, Siam, China, Ivory Coast, and possibly in South America. In North America tektites were recognized first in 1936. Excellent flow structure in tektites is outlined by adjacent schlieren of different chemical compositions which etch differentially and produce the distinctive weathered surface. Flow structure in obsidian is outlined by crystallites and vesicules, and consequently etched obsidian is free of fine flow lines and resembles tektites only in the coarser etch markings.

Tektites definitely are not of igneous origin. The prevalent assumption is that they are meteorites. Tektites correspond closely in chemical composition to clastic sedimentary rocks ranging from shale to sandstone. The writer identified small included glass particles in tektites as lechatelierite, which must have been originally grains of quartz or other nonhydrous silica. They were melted during the process of tektite formation, and their presence probably excludes a meteoritic origin.

Lightning may produce tektites. Glass formed by power line short circuits through soil contains lechatelierite particles. This glass very closely resembles tektite glass and when artificially etched develops a typical tektitelike surface. Observations are needed on the effect of lightning upon clastic sedimentary rocks and their soils.

TRIASSIC OF ANSON COUNTY, NORTH CAROLINA

BY WILLARD BERRY

The Triassic sediments of Anson County, North Carolina, can be tentatively divided on the basis of mechanical analysis into two units that are equivalent to the Pekin and Sanford of the Deep River area. Coal has been reported but has not been found by the author. If it is present it should represent the coal measures of the Deep River area. Two inliers of Carolina slate are present in the Triassic near the west side of the basin; they are apparently islands of slate, not large fragments. The fault boundaries are not sharply defined because of subsequent erosion. No fossils have been found except microscopic fragments of coal.

ORGANIC CONTENT OF CORES FROM GULF OF MEXICO OFF MISSISSIPPI DELTA

BY H. J. BISSELL*

More than 200 samples from 24 Piggot cores have been analyzed for organic content. Reducing power was determined by the chromic acid method for all samples, and 15 to 20 per cent were analyzed for organic carbon by wet combustion, and for nitrogen by the Kjeldahl method.

Excluding a few thin beds of coarse silt and very fine sand, the samples show a minimum of 2 per cent organic matter, with many beds containing more than 4 per cent. Near shore samples from the subaqueous part of the delta are notably darker than those from deep water, probably due to an abundance of terrigenous humus. They are, however, only slightly higher in organic content than the predominantly light-colored deep-water sediments.

Cores from deep water show a slight decrease in organic content with depth below the surface, while in those from near shore no such relationship is evident. All cores, however, show a decrease in nitrogen with depth; a rapid decrease for the first 3 or 4 feet, followed by a slow decrease. Thus the C/N ratio increases toward the bottom of the core. (Geological Society project.)

* Introduced by R. Dana Russell.

BLACK BEACH SANDS OF GUATEMALA, CENTRAL AMERICA

BY MARGARET FULLER BOOS

The black beach sands of Pacific Central America extend from southern Mexico to northern Nicaragua. At San José, Guatemala, 66 per cent of the sand consists of minutely pustulate, highly magnetic, rounded grains of gleaming black magnetite 1-2 millimeters in diameter. The amount of magnetite decreases markedly close to mouths of streams.

Chemical analyses show traces of tungsten, titanium, and 20-30 per cent of silica. Rare yellow topaz, jagged clear glassy quartz, rounded sphene, chips of black obsidian, minute dull red jaspery quartz and numerous smooth rounded grains of gray andesite dotted with minute octahedrons of magnetite occur with the magnetite.

Eruptions of volcanoes along the Sierra Madre sprayed the region with andesite fragments loaded with magnetite. Wave action pounded out the magnetite grains and concentrated them in the strand areas.

SPECTROSCOPIC DISTRIBUTION OF MINOR ELEMENTS IN IGNEOUS ROCKS FROM JAMESTOWN, COLORADO

BY JOSEPH M. BRAY*

Spectrographic analyses of a group of igneous rocks and their constituent minerals from Jamestown, Boulder County, Colorado, revealed:

Qualitative Analyses

Rocks: Each, regardless of age, is distinguishable by variations in content of certain elements (Sc, La, Ce, Nd, Zr, V, Cr, Co, Ni, Pb, and Zn). Comparison with several Massachusetts rocks emphasized the province relationship.

Minerals: Minor elements occur systematically. Sr is highest in K- and Ca-minerals (particularly feldspars); Ba in K-minerals (potash feldspar and hornblende). All quartz and sphenes contain Al. Sc is most abundant in Mg- and Fe^{II}-minerals (micas and hornblende). Sphenes contain a remarkable proportion of rare earths. Ti, Mn, V, and Cr are concentrated in the dark minerals and muscovite. Ni and Co occur almost exclusively in biotite.

Quantitative Analyses

Quantitative analyses substantiated all conclusions based on qualitative work.

Minerals: Characteristic minor elements of each mineral vary from rock to rock. The SrO:BaO ratios decrease numerically in the order of plagioclases, biotites, K-feldspars, and muscovites. Pegmatitic K-feldspars have much larger SrO:BaO ratios than parent rock samples. This is explained by temperature-crystal structure relations. Qualitatively and quantitatively each pegmatitic mineral contains less of almost every minor element than the same mineral in the parent rock. This also is explained by temperature-crystal structure relations.

The minor elements are probably present in solid solution.

CORRELATION OF EARLY PALEOZOIC SECTIONS IN CENTRAL AND WESTERN TEXAS

BY JOSIAH BRIDGE

Early Paleozoic rocks crop out in the Central Hill Country, the Marathon Basin, the Van Horn area, and the El Paso area. Upper Cambrian strata are well represented in the Central Hill Country, are present in the Marathon region, and are

*Introduced by W. H. Newhouse.

absent in the western areas. The Bliss sandstone of the Van Horn region, formerly classed as Upper Cambrian, contains a Lower Ordovician fauna that can be correlated with the lowest Ordovician horizon in the Ellenburger limestone of the Central Hill Country and with the younger fauna found in the boulders of the Woods Hollow shale of the Marathon Basin. This fauna has not yet been found in the Bliss sandstone of the type area around El Paso, but the correlation between the Van Horn and El Paso regions seems to be well established by other criteria. The lower part of the El Paso limestone is correlated with the upper part of the Ellenburger, and there is no equivalent of the upper part of the El Paso in the Central Hill Country.

SOURCE OF BEACH SANDS ON GULF COAST OF TEXAS

BY FRED M. BULLARD

The value of correlations based on "heavy minerals" is tested on the sands now being deposited on the beach of the Texas Gulf Coast. The principal rivers each carry a distinct suite of heavy minerals. The primary source of the major portion of Rio Grande sand is indicated by 65 per cent of basaltic hornblende and pyroxene, 15 per cent green hornblende, and only 30 per cent of the stable minerals such as garnet, zircon, rutile, tourmaline and staurolite in the heavy mineral residue. The Nueces, San Antonio, Brazos, Trinity, and Sabine rivers derive their load largely from sedimentary formations giving a high content of stable minerals with only minor amounts of hornblende and pyroxene. The Colorado River derives its load from both primary and secondary sources. Its suite of heavy minerals is more than 60 per cent green hornblende; the remainder is more stable minerals.

From the Rio Grande northward along Padre Island beach the characteristic Rio Grande suite of heavy minerals, rich in basaltic hornblende and pyroxene, gradually gives way to the Colorado suite rich in green hornblende. The influence of the Nueces, San Antonio, and Brazos rivers is clearly shown by an increased ratio of more stable minerals.

Along the southern two-thirds of Padre Island beach the modal grain diameter is ¼ mm., and the mode constitutes about 90 per cent of the total. The influence of Nueces River on the sands of Mustang Island and the northern end of Padre Island is the higher percentage of ⅛ mm. grain size although the mode remains the same. The influence of the Colorado, Brazos, and other streams can be detected in the sorting of the beach sands.

BOMB CRATERS IN DIFFERENT SOILS

BY E. M. J. BURWASH

The growing importance of aerial warfare warrants a study of the bomb craters formed in various soils and their effects on the destructiveness of the explosions. Observations made at Etaples, France, during the war of 1914-1918 yielded the following results:

(1) In a dry chalk formation the materials ejected were fine and somewhat widely distributed. The crater was large and bowl-shaped.
(2) In wet silt a bowl-shaped crater of about half the dimension of (1) was produced. The silt was arranged in large blocks close to the crater, with finer material at a slightly greater distance.
(3) In damp till the crater was intermediate in depth between the first and second described. It was conical and narrow at the top, the depth being twice the width of the orifice at the surface while in (1) and (2) the reverse ratio held. The materials were ejected at high angles and descended almost vertically.

(4) In loose sand a very shallow saucerlike depression resulted allowing horizontal dispersion of bomb fragments and greater danger in the surrounding area.

ORE-BEARING PIPES IN THE TARRYALL RANGE, COLORADO

BY ROBERT D. BUTLER AND L. B. RILEY *

A number of small pipelike deposits in red granite have been opened by prospectors on the western slope of the Tarryall Range. Their diameters range from 5 to 8 feet, and an ideal cross section is circular, although they may be oval, semicircular, or rectangular. Metallic minerals present are: earthy hematite, pyrite, sphalerite, galena, chalcopyrite, and molybdenite. Gangue minerals are quartz, muscovite, and fluorite. Concentric alteration zones surrounding the pipes consist of bleached and silicified granite. Although pneumatolysis may have played a role in the formation of the pipes, an explanation involving only hydrothermal deposition is also tenable. The deposits resemble in most respects certain tin-bearing pipes in South Africa.

COLUMNAR LIMESTONE PRODUCED BY SUN-CRACKING

BY GEORGE HALCOTT CHADWICK

In recent literature on columnar jointing in limestone no mention is made of the wide occurrence of such jointing in the Manlius (Olney) limestones of eastern New York and the Bossardville limestones of eastern Pennsylvania. This jointing was noted by the early geologists and is familiar to all later workers in this region. The outcrops are near the shoreward edge of these sediments, and as the columnar strata are "ribbon-banded" (straticulate) it seems clear that the joints were produced by repeated sun-cracking of the lime-mud sediments (calcilutyte) on a tidal flat. This structure occurs at several levels in the "Waterlime" group and in places persists through a thickness of several feet of these deposits. This is therefore both the first described and the outstanding illustration of this phenomenon in America.

SUBSURFACE STUDY OF THE ELLENBURGER FORMATION IN WEST TEXAS

BY TAYLOR COLE †

Various portions of the Ellenburger (lower Ordovician) formation have been penetrated throughout the West Texas area bounded by Latitude 32° and 30° and Longitude 101° and 103°. The formation consists of fine to coarsely crystalline dolomites and dense limestones. These lithologic units are of no value even in local correlations when accurate work is desired.

A careful study has been made of the insoluble residues from most of the well cuttings available. The chief criterion for correlation is chert. Four main classes of chert are recognized: smooth, granular, chalky, and druse. Each class has several secondary characteristics, and gradational types are present. From this work the complete Ellenburger section, which is approximately 1390 feet thick in western Crane County, has been divided into five zones. These zones have approximately the following relationship with the faunal zones of Dake and Bridge:

Zone 1	Cotter
Zone 2	Jefferson City Roubidoux Gasconade
Zone 3 Zone 4 Zone 5	Eminence Potosi

* Introduced by P. F. Kerr.
† Introduced by H. P. Bybee.

Chert zones have made it possible to locate accurately the stratigraphic position entered in the dolomite section. The upper part of the Ellenburger has been truncated in four wells in the Big Lake Field (Reagan County). Restoration of the truncated part shows the axis of the folding to be parallel to the Permian folding (San Andres) which runs NW-SE rather than N-S.

About 275 feet of Ellenburger is absent from the base against the Apco Ridge (Pecos County) probably due to overlap, and about 1000 feet has been eroded from the top of the section in this area.

CHAZYAN AND BLACK RIVER STRATIGRAPHY IN TAZEWELL COUNTY, VIRGINIA*

BY BYRON N. COOPER AND CHILTON E. PROUTY

Twenty-eight faunal and lithologic units are recognized in the 1000-1500 feet of Stones River, Blount, and Black River beds southwest of Bluefield, Virginia. Detailed tracing of these units in Tazewell County shows that most of the beds which have been assigned to the Blount group are of Stones River and Black River age. Some of the coarse-grained limestones which have been called Holston underlie beds containing a Murfreesboro fauna, whereas other so-called Holston beds occur above limestones containing Lowville fossils. Certain fossils which have been thought to be indicative of the Ottosee occur below beds carrying Murfreesboro fossils. Nodular, bryozoan limestones previously assigned to the Ottosee overlie limestones containing Lowville fossils. The name Mosheim has been applied to two different units which are separated by 200-500 feet of beds. The limestones which have been called Lenoir in the western part of Tazewell County are considerably older than the sequence of beds assigned to the Lenoir in the northeastern part of the county. Changes in the nomenclature and classification of the Chazyan-Black River sequence are tentatively proposed.

RECENT RECESSION OF DINWOODY GLACIERS, WIND RIVER MOUNTAINS, WYOMING

BY DAVID M. DELO

The Dinwoody Glaciers were first studied in 1930 by Wentworth and Delo, who compared them in size and activity with other large glacial groups in the western United States. The writer again made observations on these glaciers in September 1940 and noted that extensive recession and morainic construction had occurred during the intervening decade. These changes are described, and glacial features present in 1930 are contrasted with those seen in 1940. Trends noted in the Dinwoody Glaciers are also compared with general trends in other glacial groups in the western United States and correlated with climatic trends evidenced by weather observations in the same area.

GLACIAL DEPOSITS OF THE CANAAN AREA, NEW HAMPSHIRE

BY CHARLES S. DENNY†

A maturely dissected upland of igneous and metamorphic rocks is discontinuously veneered by till. Over much of the area the till is brownish to yellowish gray, very compact, has a good cleavage, and no topographic expression. This till was probably deposited under active ice. Some of the till, especially near the valley bottoms, is

* Published with the permission of the State Geologist of Virginia.

† Introduced by J. W. Goldthwait.

light gray to white, loose-textured, and sandy. This type contains more boulders than the more compact variety and gives rise to hummocky topography. The loose till is probably englacial and subglacial material deposited during deglaciation, perhaps marginal to active ice tongues. The loose till rests locally on the more compact variety. Hummocks on the sides of major valleys are composed of loose sandy till intermingled with very poorly sorted sand. This relation suggests a transition from active to stagnant ice. The possibility that there was more than one advance of the ice during Wisconsin time is being considered. Abandoned stream channels across ridges and on valley sides resulted from ice marginal drainage at the edge of a downwasting ice sheet with a southerly slope. Kames, kame terraces, and eskers near the valley floors are composed predominantly of sand overlain in most places by a few feet of gravel. These fluviatile deposits which locally show delta structure were built in association with ice, locally detached and probably stagnant, which filled the valley bottoms. There is no clear evidence of wide open lakes during deglaciation. (Geological Society project.)

TREND OF CHANGES IN THE LATE TERTIARY PRAIRIE

BY MAXIM K. ELIAS

Distribution of the two prairie climaxes of Nebraska, mixed prairie in the west and true prairie in the east, is controlled by the mean annual rainfall. If the rainfall were to increase the true prairie would advance westward, and if the rainfall were to decrease the mixed prairie would shift eastward.

The similar changes of the Tertiary prairie vegetation in Nebraska from xeric to mesic and back to xeric again probably were responses to similar climatic control, but the peculiar developments at the very end of Ogallala time were more likely controlled by a steady rise of water-table level. Such rise could account for the observed change from the typical luxurious prairie vegetation to only few selected grasses indicative of moist and even periodically submerged ground. Likewise observed lithologic changes indicate development of marshy ground and eventually of a group of very extensive though very shallow lakes.

The rise of water-table level probably was controlled by gradual leveling of the plain combined with gentle westward tilting. The cause of tilting is seen in isostatic adjustment in order to compensate increased load in the west due to deposition of the Tertiary sediments, and decreased load in the east due to continuous erosion east of the High Plains throughout Tertiary time.

The beginning of a new cycle of erosion in post-Ogallala time probably was caused by world-wide lowering of base level of erosion. If so, this event could be accepted as marking a natural division between Pliocene and Pleistocene.

PETROFABRIC NOTES ON QUARTZ LAMELLAE IN AJIBIK QUARTZITE, MICHIGAN

BY H. W. FAIRBAIRN

A specimen of sheared, unrecrystallized Mesnard quartzite from the Marquette district, Michigan, shows lamellae in many quartz grains. Petrofabric study shows the following relations. A diagram of 613 crystal axes, selected without regard to presence or absence of lamellae, indicates random orientation. A second diagram of 364 axes of grains having lamellae bears some resemblance to the common girdle diagrams of recrystallized quartz fabrics. A third diagram of poles to lamellae

shows marked orientation. Two sets of lamellae are developed which are symmetrically inclined to the visible foliation of the quartzite. Eighty per cent of these lamellae occur in grains in which the angle between the crystal axes and lamellae poles ranges between 7 and 36 degrees. It is suggested that part of the difficulty of interpretation of girdle diagrams of recrystallized quartz fabrics may arise through disregard of possible lamellae development at an earlier stage, with which is associated the irrational angular relation with the crystal axes.

PETROFABRIC ANALYSIS OF DOLOMITE

BY H. W. FAIRBAIRN AND H. H. HAWKES

Coarsely crystalline dolomite specimens from the Plymouth-Rochester area, Vermont, and the Clair River syncline, Ontario, show abundant $(02\bar{2}1)$ polysynthetic twins. The orientation of dolomite, heretofore incompletely known in tectonites, has been determined. It is analogous to calcite, the steep $(02\bar{2}1)$ rhombohedron probably acting as a deformational twin plane instead of the flat $(01\bar{1}2)$ plane. The experimental data available for calcite are lacking, however, for dolomite. Two maximum concentrations of the long diagonal in $(02\bar{2}1)$ lie symmetrically on either side of the rock foliation. Assuming that this long diagonal is the glide line (analogous to the known glide line for calcite), the direction senses of the lines in each of the two maxima are consistent, but the maxima themselves show opposed direction senses. This suggests that the compressive forces producing the twins acted in the obtuse sector between the two maxima. This application of direction sense in petrofabric study is believed to have considerable possibilities and has not been used previously.

PROPOSED GLACIAL MAP OF NORTH AMERICA

BY RICHARD FOSTER FLINT AND EARL T. APFEL

The Division of Geology and Geography of the National Research Council has recently set up a committee charged with compiling a glacial map of North America. The committee's object is to place on a single map our present knowledge of the glacial geology of North America, gathering together all available data, in considerable part unpublished, and to some extent the by-product of field work not primarily glacial. It is hoped that in consequence new relationships will become plain, and intelligently planned research will be thereby stimulated. Designed primarily for research purposes, the map probably will find secondary use in the classroom.

The scale tentatively selected for final publication is 50 to 60 miles to the inch. The map will show the limits of the several drift sheets; interglacial localities; striae, boulder trains, and drumlin axes; terminal moraines; large esker systems; Cordilleran ice divides; extraglacial outwash; major glacial lakes; glacial marine limits; and distribution of loess. The map may be accompanied by text material containing descriptions, interpretations, and source references.

The committee in its present form consists of 12 American and 4 Canadian members, constituting a broad representative group. Both the Geological Survey of Canada and the United States Geological Survey are officially represented. Each member has assumed responsibility for the compilation of data for some part of North America. In the United States the subdivisions have been drawn, for convenience, along State boundaries.

In order that the map may be widely useful, criticism, suggestions, and specific glacial data are earnestly solicited.

EMPIRE MOUNTAINS, SOUTHEASTERN ARIZONA

BY F. W. GALBRAITH*

The Empire Mountains, 30 miles southeast of Tucson, Arizona, form a small but rugged Basin Range with northeasterly trend, a pronounced western escarpment, and a broad eastern pediment. Paleozoic rocks, 3300 to 6500 feet thick, include the Upper Cambrian Abrigo formation, Upper Devonian Martin limestone, Lower Mississippian Escabrosa limestone, Lower Pennsylvanian Naco formation, and the Permian Manzano and Snyder Hill formations. Of particular stratigraphic interest are the thick beds of marl and gypsum in the lower Manzano and the massive quartzites and limestones of the upper Manzano. These are probably to be correlated with the Yeso and San Andres formations of New Mexico, not previously known to have such wide distribution in southern Arizona. The Paleozoic rocks are overlain by a thick series of Upper Cretaceous clastics.

The dominant structural feature of the Empire Mountains is a low-angle fault which dips to the southeast. On this fault the entire Paleozoic mass has moved over the Upper Cretaceous sedimentaries. A block of Paleozoic rocks resting on Tertiary sediments a few miles to the north dates at least part of the overthrusting as late Tertiary.

Large tear faults accompanied, and smaller normal faults followed the overthrusting. A stock of quartz monzonite invaded the central part of the range, doming and altering the rocks of the overthrust block. Intrusion was later than the overthrusting and possibly concurrent with the normal faulting.

Detailed study of the Empire Mountains and reconnaissance in the neighboring ranges appear to indicate that thrust faulting is an important factor in the development of Basin and Range structure in southeastern Arizona.

MEASUREMENT OF TERRESTRIAL RADIOACTIVITIES

BY CLARK GOODMAN AND ROBLEY D. EVANS †

For uranium or radium analyses, ionization chamber and electrometer techniques are satisfactory for the measurement of 10^{-12} curie or more of radon, while alpha-ray pulse counters are preferable for weaker samples. For thorium analyses on rocks, chemical separation of ThX provides a parent solution from which the short-lived gas, thoron, can be liberated and flowed continuously through an ionization chamber.

Much of the data on terrestrial radioactivity, especially in the older literature, requires revision. Determination of the geologic age of an igneous rock primarily involves the measurement of the helium content and the rate of production of helium (rate of emission of alpha particles) per gram of specimen. The latter can be calculated for the U, Th, and Ac series from the radon and thoron content. A direct physical method, independent of standards, decay constants, and possible samarium interference is provided by counting the alpha rays emitted from very thin layers of rock sample. The U, Ac, and Th content of a rock can be computed from a comparison of the alpha-ray count and a separate radon analysis of the same material. Mean values of radium content, in 10^{-12} g Ra per g rock, and the ratio of thorium to uranium for specimens analyzed recently are as follows: Ra: 1.7 ± 0.2 for 26 acidic rocks; 0.51 ± 0.05 for 7 intermediate rocks; 0.34 ± 0.03 for 41 basic rocks; 0.70 ± 0.12 for 13 sedimentary rocks. Ratio of Th/U: 4.3 for 16 acidic rocks; 2.6 for 6 intermediate rocks; 4.0 for 35 basic rocks. (Geological Society project.)

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*Introduced by B. S. Butler.

†Introduced by W. J. Mead.

ORBICULAR ROCK FROM BUFFALO HUMP, IDAHO

BY G. E. GOODSPEED

Orbicular rocks are well exposed in several road cuts and glaciated surfaces about a mile southeast of Buffalo Hump along the road between Calendar and Humptown, Idaho. Although this area is well within the exposed surface of the Idaho batholith, remnants of quartzite, schist, and gneiss, presumably of the Belt series, are nearly equal in areal extent to Mesozoic granodioritic rocks. Pegmatite and aplite dikes are common.

The orbicules consist mainly of radiating and perthitic intergrowths and range in size from a fraction of an inch to several inches in diameter. Some occur in schist, others are transitional into pegmatite. Some of the orbicules have for their center a fragment of schist, and many of them have centers showing a slight schistosity. Included minerals in the feldspars indicate crystalloblastic growth. Ringlike inclusions of mafics in the feldspars suggest a recurrent feldspathization. Some of the orbicules have formed in zones of shearing as shown by their relation to slickensides, and some are traversed by pegmatite veins.

A complete sequence from groups of feldspar porphyroblasts in schist to fully formed orbicules in schist indicates a metasomatic rather than a magmatic origin. The gradation from a schist with orbicules to a rock composed chiefly of orbicules coupled with the presence of schist cores is highly suggestive that this orbicular rock was formed by metasomatic processes.

EXPERIMENTS IN DYNAMIC METAMORPHISM

BY DAVID GRIGGS

New apparatus makes it possible to produce in the laboratory an environment in which all five of the metamorphic variables are controlled. The introduction of high temperatures and mineralizing solutions to the previously attained conditions of high confining pressures, high shear stress, and long duration produces striking results in the deformation of rocks. Quartz, which resisted all previous efforts to deform it, becomes highly mobile under these conditions of solution and recrystallization. Quartzite is readily formed from sand grains. Dolomitization can be controlled, and the importance of dolomitization in the deformation of limestones is discussed. Preliminary attempts to produce the more complicated low-grade metamorphic changes have met with indifferent success but serve perhaps to illustrate some of the complexities of metamorphic processes. (Geological Society project.)

FOLDED THRUST FAULTS IN THE FOOTHILLS OF ALBERTA

BY B. F. HAKE, ROBIN WILLIS, AND C. C. ADDISON*

This paper describes the stratigraphy and geologic structure of an area in the Rocky Mountains foothills of west-central Alberta. An unusual group of low-angle thrust faults is described and analyzed. At least seven overlapping faults were recognized which range up to 30 miles in length and have an aggregate displacement of about 6 miles. They divide the incompetent Upper Cretaceous sediments into thin sheets. The faults and faulted sediments have been strongly folded. These faults are thought to have developed in an asymmetrical syncline where the structural development required more bedding-plane slippage than the strata were

* Introduced by Robin Willis.

capable of performing, and the faulting was the means by which relief was obtained for the stresses involved. The faults are believed to be confined to the stratigraphic section and the major structure with which they are found associated and to die out completely with depth without producing any dislocation of Paleozoic rocks.

EARTH MOTIONS IN THE VICINITY OF A FAULT SLIP

BY N. H. HECK AND FRANK NEUMANN

Existing lack of knowledge regarding the mechanism of fault slipping and resultant earth motions is in part supplied by new and important displacement data now available for the Imperial Valley earthquake of 1940 and the Long Beach earthquake of 1933. The ground displacements were not recorded directly but obtained by mathematical treatment of seismograph acceleration records. The accuracy of the original and deduced records has been proved adequate.

Complete interpretation of the motion at El Centro, in Imperial Valley, covering a displacement range of 35 cm., is not possible because instruments begin operating after earthquake motion starts, and absolute time control is not adequate. El Centro is 7 miles northwest of epicenter and 5 miles southwest of nearest point on the clearly defined fault. All major wave types observed at near-by and distant points, including surface waves, appear from this investigation to have their genesis in a relatively small epicentral area and to follow accepted laws of seismic wave transmission at very short epicentral distances. The El Centro motion is not dominated by the direction of slipping, although the character of some motion is probably controlled by it. A major oscillatory motion occurs almost normal to direction of the fault, a fact also outstandingly true of the Long Beach earthquake motion recorded in Los Angeles. Results show how data complete from the start might be used to check the validity of the elastic rebound theory and detect permanent displacement, if any, at station. Other related phenomena of geological interest are discussed.

PIPETTE-HYDROMETER METHOD FOR SIZE ANALYSIS

BY N. N. HELLMAN AND V. E. MC KELVEY*

A small, sensitive hydrometer, reading in grams per liter, is enclosed within a pipette case similar to that holding the ordinary battery hydrometer. Pipette samples are taken from a suspension of known concentration as in the standard pipette method; instead of drying and weighing the sample, the concentration of the suspension in grams per liter is read from the hydrometer within the pipette case. The method is rapid and is well within the usual accuracy of sampling and dispersion. Since the pipette samples are taken from a known depth of the suspension some of the faults of the Bouyoucos hydrometer method are eliminated.

This method should greatly extend the application of size analysis inasmuch as it eliminates the tedious weighings involved in the pipette method. The original concentration of a suspension can be measured directly with the hydrometer, and the method can thus be used for the rough analysis of fine-grained materials in the field. The only apparatus required either in the field or in the laboratory for the analysis of fine-grained sediments by this method consists of the hydrometer itself, a cylinder or jar of at least a liter capacity, and a 200 mesh sieve. A rough balance and some dispersing apparatus are desirable but not necessary.

* Introduced by W. H. Twenhofel.

STRUCTURAL TYPES AND TRENDS IN CENTRAL WESTERN WYOMING

BY LELAND HORBERG, VINCENT N. NELSON, AND VICTOR CHURCH

The area extending southeastward from the south end of Teton Basin, Idaho, to the northern portion of Green River Basin, Wyoming, exhibits a series of foreland and geosynclinal structures of Laramide age modified by Tertiary high-angle faults. Included within the area are portions of the Teton, Gros Ventre, Hoback, and Snake River ranges.

Along the Gros Ventre-Teton axis, foreland structures are represented by broad, asymmetrical anticlines, a major northeast-dipping thrust fault, and three high-angle, trapdoor faults. These were developed during an early phase of the Laramide Revolution and, as buttresses, controlled the trend and character of the later geosynclinal structures developed adjacent on the south. The latter structures are characterized by close folds and low-angle, southwest-dipping thrust faults. Major thrusts of this type are the St. John, Absaroka, Darby, and Jackson faults. Thrusting generally preceded deposition of early Eocene (Almy) conglomerates, although local subsequent movement occurred at one point. Cenozoic faulting of Basin-Range type and north-south trend transects earlier structures and is responsible for the impressive east scarp of the Teton Range, small fault blocks rising from the floor of Jackson Hole, and the west boundary fault of the northern Hoback Range. Renewed movements along the trapdoor faults in the Gros Ventre Range also occurred during the Tertiary.

Although regional stratigraphic relations seem to have had an important effect on both the type and trend of Laramide deformation, this influence cannot be recognized in Tertiary movements. (Geological Society project.)

PEDIMENT GAPS OF THE SACATON MOUNTAINS, ARIZONA

BY ARTHUR DAVID HOWARD*

Theories of pediment origin emphasize either lateral planation or the combined activity of weathering and transportation. Pediment gaps were studied in an attempt to evaluate these processes.

Gaps are formed by headward extension of pediment embayments across the divide. Their longitudinal profiles are convex, and their smooth floors locally meet the side slopes at a sharp angle. Both lateral planation and "weathering-transportation" seem competent to produce the profile. Near the divide the diminishing debris from the wasting mountains requires a lesser gradient for its transportation; farther away the added pediment debris necessitates a steeper slope.

The smooth floors and their angular junction with the side slopes require lateral planation. If the drainage lines of a gap or embayment were fixed, the more recently formed parts of the floor would be undulatory, because instream areas are separated by streams of varying size and declivity. If there were no lateral cutting, the foot of the side slopes, frequently protected by talus, would not weather back so rapidly as the higher slopes. Eventually the slopes would be reduced to gentle declivity; actually they remain parallel during recession.

"Weathering-transportation" dominates only in the holing-through of gaps. Headward growth of embayments prior to holing-through, and subsequent recession of gap walls, are the work of lateral planation. Slopes recede principally by weathering,

* Introduced by Douglas Johnson.

except at their base. The foot of the slope is the head of the pediment, and it is here that lateral planation dominates. It is therefore concluded that lateral planation is essential to pediment development. (Geological Society project.)

INVESTIGATION OF HELIUM RETENTION IN COMMON ROCK MINERALS FOR THE PURPOSE OF AGE DETERMINATION

BY PATRICK M. HURLEY AND CLARK GOODMAN*

In the helium method of age determination the age of the material to be tested is given by the ratio of the content of helium to the content of radioactive elements in the material. In an unaltered igneous rock, where presumably the minerals are of the same age, it would be expected that the distribution of helium in the various minerals should correspond with the distribution of the radioactive elements. In each mineral the ratio of helium to radioactivity should be the same. This was found to be not the case.

Pyroxene and feldspar were separated from six samples of Triassic diabase. Age measurements on each yielded a mean "age" of 103 millions of years for the pyroxene samples and 36 millions of years for the feldspar. Six samples of late Triassic magnetite from ore occurrences in West Virginia, Pennsylvania, and Nova Scotia all gave "ages" closely grouped about a mean value of 132 millions of years. The constant age ratio, despite widely varying content of radium and thorium, suggests that the magnetite has retained most of its helium.

Further work on magnetite specimens of various geological ages appears to show an age sequence and spacing compatible with geological knowledge.

It is concluded that helium age measurements made directly on rocks, especially those containing feldspar, are likely to be in error owing to loss of helium but that possibly more acceptable helium ages may be obtained by analysis of certain minerals believed to retain their helium. (Geological Society project.)

SOME FEATURES OF ORIGIN OF QUARTZ VEINS AT GRASS VALLEY, CALIFORNIA

BY EARL INGERSON

Presence of low quartz, alteration of feldspar to sericite, and of hornblende and biotite to chlorite indicate a temperature of less than 500° C. for the main part of the vein formation at Grass Valley. Abundant carbonate shows that the solutions were rich in carbon dioxide. Laboratory experiments show that carbon dioxide decreases the solubility of silica either in pure water or in solutions containing alkalies. It appears, therefore, that an "ore magma" with the components of the veins, plus water, is not possible and that the solutions must have been dilute.

Study of asymmetric zoning in the quartz and of asymmetric deposition of minerals on quartz crystals in vugs indicates that the solutions moved in the veins approximately parallel to the ore shoots—*i.e.*, up from the southeast for the Idaho-Maryland veins. If this direction persists to the source of the solutions that formed these veins, they cannot have come from the granodiorite cupola at Grass Valley but must have been derived from the more deeply buried granodiorite to the east.

Many of the smaller veins appear to be drag-folded near thrust faults. The quartz fabric indicates, however, that the folding is all pre-quartz. The quartz is granulated and shattered by later movements along the faults but has not been plastically deformed. On a larger scale nondeformation of the quartz, except granu-

*Introduced by W. J. Mead.

lation, is indicated by the independence of the fabric elements of the quartz and of the country rock. (Geological Society project.)

TACONIC DISTURBANCE AND ASSOCIATED EVENTS

BY G. MARSHALL KAY

Stratigraphy of the region from western New England to Michigan evidences a series of events culminating in the post-Ordovician Taconic Disturbance. An effect of great thrusting is the emplacement of the Taconic Allochthone of clastic Cambrian and Ordovician upon equivalent autochthonous calcareous facies in Quebec, western New England, and New York; displacement is at least 50 miles. The tectonic contact of allochthone on late Ordovician, its overlap by indigenous upper Silurian, and the unconformability of early Silurian on autochthonous Ordovician date the deformation. Thrusts developed along the west flank of the Quebec Barrier that separated early Ordovician facies. Ordovician clastics of the autochthone came from a land (Vermontia) whose transposed core, the present Green Mountains axis, was raised within the Magog Trough east of the barrier in middle Trenton time. The Adirondack belt subsided less than the adjoining troughs during early Mohawkian time and was later block faulted, probably in early Silurian. The Allegheny Synclinorium belt had a trough along its eastern margin in early Black River, but there are persistent thicknesses of younger Mohawkian limestones to beyond the present Cincinnati axis. Later Ordovician clastics evidence a semilenticular depression, centered in eastern Pennsylvania. Early Silurian sediments first show influence of a Cincinnati Arch, Upper Ordovician shales crossing its position without significant change; it is a synorogenic Taconic structure. The greater quantity of Ordovician than Silurian clastic sediment implies that the principal highlands were those of the mid-Ordovician; the front of the Taconic thrust sheets did not reach important elevation.

PALEOGEOGRAPHIC STUDIES OF THE MESOZOIC IN NORTHERN MEXICO

BY LEWIS B. KELLUM

Epicontinental seas invading North America via Mexico during the Mesozoic were small in Triassic time and reached maximum extent during the Lower Cretaceous. Mountain building and withdrawal of the seas is evidenced by the distribution, lithology, and faunas of Upper Cretaceous deposits. The sequence of events is reflected in the life and character of the marine and continental deposition above the margins of the Gulf. Only many years of co-operative detailed study will cover all parts of this great body of water which spread from Mexico northward into the central United States. Typical well-exposed stratigraphic sections along its margins have been selected for intensive study. These represent the transition from marine to continental environments and show the variations of structural development with respect to the shifting coast line. Studies on the Coahuila Peninsula have been published. A correlation of events in several selected areas should give a fair picture of events in the epicontinental sea as a whole throughout the Mesozoic. The margins of the eastern extensions of this sea are buried unconformably beneath the Tertiary of the Gulf Coastal Plain in east Texas, Louisiana, and Alabama. Stratigraphic and structural studies in the selected areas of exposed Mesozoic rocks should aid in the interpretation of subsurface data in concealed areas. Co-operative study of a selected area in northern Chihuahua and eastern Sonora, along the western margin of the epicontinental seas of the Mesozoic, is proposed.

OCCURRENCE OF PINITE ROCK

BY PAUL F. KERR AND WILLIAM W. LOMERSON

A large mass of sericite, samples of which invert to mullite on calcination, occurs in the Humboldt Range, Nevada. Associated with the sericite are alumino-silicates, which it is believed are responsible for the unusual thermal behavior. The mass is thought to have been originally a fine tuff or ash which has been altered by hydrothermal metamorphism to a rock consisting in large part of finely crystalline potash mica. The name pinite is suggested as a rock term to be applied to such a mass. The principal associated rock units of the area are rhyolitic volcanics of the Koipato formation overlain by the Middle and Upper Triassic Star Peak limestones. The pinitized zone lies near the crest of a northward-trending ridge on the south side of South American Canyon just below the contact between the volcanics and the limestones in a member of the series similar to the Rochester trachyte of Knopf.

Topographic and geologic maps of the deposit have been prepared, and laboratory examination has involved microscopic, X-ray, and chemical study.

EFFECTS OF ABRASION ON THE SIZE, SHAPE, AND ROUNDNESS OF ROCK FRAGMENT

BY W. C. KRUMBEIN

Earlier work on the abrasion of rock fragments in tumbling barrels is reviewed, and the main principles are summarized. Most earlier work concerned one or another aspect of abrasion, without including interrelations among particle characteristics during wear. Experimental data are presented, including measurements of size, sphericity, and roundness during abrasion. The relative rates of size reduction, rounding, and shape change were determined, and it was found that the coefficient of rounding has the largest value, shape change is intermediate, and the coefficient of size reduction is smallest. An analytical theory of abrasion is developed on the basis of the experimental data, and it is found that simple exponential functions yield at least first approximations to the complex process of particle wear.

Geological applications of tumbling barrel data are discussed, and it is emphasized that wear of rock fragments is only one aspect of the changes sediments undergo during transportation. The selective effects of transportation, in terms mainly of size, shape, and density, must be taken into account in any analysis of actual field relations.

SIGNIFICANCE OF HILLSIDE CHANNELS IN LATE PLEISTOCENE ICE RECESSION

BY RICHARD J. LOUGEE*

Morainal deposits are not uncommon but are fragmentary and discontinuous in New England valleys. Nevertheless, information may be obtained about the ice edge pattern where marginal streams have left records of their courses on the sides of hills and mountains. There are ice-marginal channels in areas of rugged topography throughout New England, many of them having been produced by the release of waters from ice-dammed lakes. Those following present slopes of hills may be interpreted as of either subglacial or postglacial origin, but channels running diagonally down the hillslopes seem best explained as formed along the sides of retiring ice tongues, the configuration of which they may thereby accurately outline.

*Introduced by George Otis Smith.

Hillside channels range in form from gullylike trenches to simple benches in the till and to kame terraces of stratified material. A continuous channel system may include all these variations, depending from place to place on the erosive or depositing activity of the stream. Channel systems more than a mile long on Hubbard Hill in North Charlestown, New Hampshire, have gradients ranging between 280 and 430 feet per mile for the first mile along the margin of the Connecticut Valley ice tongue. A comparison of elevations of the upper ends of the channels and central portions of the adjacent valley floor indicates thicknesses of 700 feet of ice in the valley at distances probably less than 2 miles behind the end of the tongue.

THRUST FAULTING AT THE SOUTHERN END OF THE BIG HORN MOUNTAINS, WYOMING

BY JOHN DAVID LOVE*

Several thrust faults occur along the east and west flanks of the folded Big Horn Mountains in north-central Wyoming, but only normal faults have previously been described from the southern end of the range. The following data observed southwest of Badwater post office suggest that the southern margin of the range was thrust southward into the Wind River Basin, although Upper Eocene strata cover the actual fault zone:

(1) More than 2000 feet of Upper Cretaceous fine-grained shales and thin sandstones with an east-west strike are overturned toward the south along Badwater Creek.
(2) There is not room for the normal section in the covered area between the southward-dipping Lower Paleozoic strata on the southern end of the range and the overturned Upper Cretaceous strata directly to the south.
(3) The overturned Cretaceous strata are unconformably overlain by more than 500 feet of Paleocene or lower Eocene boulder beds containing angular masses of Paleozoic limestone, up to 30 feet in diameter, interbedded with coarse sandstones. Near the mountains these strata dip 35° S. but flatten rapidly basinward and become finer-grained.
(4) The mountain front and the Tertiary strata south of it are cut by many normal faults, some of which are post-Eocene. These faults suggest collapse of a thrust block.

The discovery of thrust faulting in this area necessitates complete revision of previous interpretations of the structural history, both of the southern part of the Big Horn Range and of the northeastern part of the Wind River Basin.

TERTIARY AND PLEISTOCENE SEDIMENTATION IN RELATION TO THE PLIOCENE-PLEISTOCENE BOUNDARY IN THE GREAT PLAINS

BY A. L. LUGN

Transition from Pliocene to Pleistocene time was marked by geomorphologic changes in the Great Plains. The four main cycles of Tertiary sedimentation in Nebraska follow a definite sequence in each cycle: (1) the erosion of shallow, relatively wide valleys trending from west to east; (2) alluviation of the valleys by channel and floodplain deposits; (3) the extension of alluviation beyond the confines of well-developed valleys over the interstream areas. The last Tertiary cycle of sedimentation culminated with the deposition of algal limestone beds in the Kimball formation.

Following the deposition of the highest Ogallala algal limestone, the advance of the Nebraskan ice in the easternmost part of the region was preceded by valley erosion

* Introduced by Carl O. Dunbar.

across the western Great Plains and the development of wide, extensive alluvial basins of erosion in southeastern Nebraska.

Significant differences exist between the Pleistocene fluviatile sediments of south-central Nebraska and the older Ogallala sands and gravels. West of the areas of Pleistocene fluviatile sedimentation, the major streams across the Great Plains developed a succession of erosional terraces which can be correlated with peneplains in the Rocky Mountains and with fluviatile and glacial deposits to the east.

The Tertiary period was a time of characteristic sedimentation over the western Great Plains where, during the Pleistocene, erosion and terrace development are significant of all post-Ogallala time. The areas of Pleistocene sedimentation were notably shifted to the eastward into close proximity with the terminal moraines of the Nebraskan and Kansan ice sheets.

LATE PALEOZOIC HISTORY OF CENTRAL OREGON

BY C. W. MERRIAM AND S. A. BERTHIAUME

Fifteen miles southeast of Paulina, Oregon, unaltered Permian and Carboniferous sediments are exposed in a small area largely stripped of former Tertiary lava covering:

(1) Triassic sandstones and conglomerates, 3500 to 4000 feet

Deformation (folding)

(2) Permian fusulinid limestones, sandy limestones, and sandstones, 900 feet. Lower Permiant absent

Deformation (local angular discordance)

(3) Pennsylvanian bedded chert, coarse conglomerate, carbonaceous sandstone, and carbonaceous mudstone, 1000 to 1500 feet. In part terrestrial with lower Pennsylvanian flora

Disconformity

(4) Lower Carboniferous marine limestones and sandstones with *Dibunophyllum, Striatifera,* and large productids similar to *Gigantella,* 900 to 1000 feet

In general the Paleozoics have suffered more intense folding than the overlying Mesozoics. Strikes of folds within the Paleozoics are locally at marked variance with trends in adjacent Triassic beds.

Abundance of coarse sandstone in all formations and thick channel conglomerates in the Pennsylvanian bespeak high-standing near-by terrain during much of late Paleozoic time in this area, with continuance of such conditions in Triassic time. Bedding of terrigenous clastics is notably lenticular; certain of the limestone bodies are also of short lateral extent. Tuffaceous material, which is to be expected here, has not yet been recognized in the Permian or Pennsylvanian sediments.

SUBMARINE MOUNTAINS IN THE GULF OF ALASKA

BY HAROLD W. MURRAY*

Reconnaissance sounding lines in the Gulf of Alaska have revealed many submarine mountains rising sharply from 1 to 2 miles above the surrounding bottom. These mountains, as contoured, are approximately 10 to 25 miles wide and 15 to 70 miles long at the base and occur singly and in groups. The groups in turn tend to form ranges which extend northwestward across the gulf. Sections of all sounding lines indicating strong relief are reproduced in natural scale profile and show additional physiographic details not revealed by contours. The discussion accom-

*Introduced by Paul A. Smith.

panying the profiles is technical as well as descriptive in that it includes an evaluation of the sounding data. The utilization of the data with a view to postulating the origin of these submarine features is not within the purpose of this paper.

MOON AS A SOURCE OF TEKTITES

BY H. N. NININGER *

Assuming that the lunar "craters" are of meteoritic origin this paper suggests that tektites have had their origin in connection with the impacts which formed those craters.

Note is taken of the fact that meteorites would encounter the surface of the moon at their full interplanetary velocities. The absence of a lunar atmosphere would allow ejectamenta to leave their points of origin at velocities above the minimum velocity of escape from the satellite whose gravitational power is only one-sixth that of the earth. Some of the fragments so ejected reach the earth as tektites.

Possibly some of the recognized varieties of meteorites also have this origin.

STRUCTURAL FEATURES OF THE VIRGIN SPRING AREA, DEATH VALLEY, CALIFORNIA**

BY LEVI F. NOBLE

A flat thrust fault of middle or later Tertiary age, believed to have followed roughly the contact of late pre-Cambrian sediments with earlier pre-Cambrian metamorphic rocks, is well exposed throughout the Virgin Spring area, 7 by 14 miles square, in the Black Mountains east of Death Valley. On this thrust late pre-Cambrian, Cambrian, and Tertiary rocks have moved relatively westward for an unknown distance. The rocks of the overthrust plate are broken into innumerable blocks and slices, which are thrust over one another to form an extremely complex mosaic. This assemblage of blocks is named the Amargosa chaos, and the flat fault upon which the chaos lies is named the Amargosa thrust. The chaos is divided into the Virgin Spring, Calico, and Jubilee facies, each characterized by certain kinds of rock. The Amargosa thrust and chaos are folded into several plunging anticlines of northwesterly trend, along whose crests the earlier pre-Cambrian rocks below the thrust are exposed.

Unconformably upon the folded thrust and chaos is the Funeral fanglomerate, probably of late Pliocene age, which includes some basaltic lava flows. These rocks are deformed by folds and faults so recent that they are still reflected in the topography; Death Valley is primarily a syncline, modified by faulting, in the Funeral fanglomerate.

Features similar to the Amargosa thrust and chaos occur throughout an area of at least 8000 square miles that borders and includes the Death Valley trough.

IGNEOUS AND METAMORPHIC ROCKS OF THE RUMNEY QUADRANGLE, NEW HAMPSHIRE

BY LINCOLN R. PAGE †

The igneous rocks of the Rumney quadrangle, located in west-central New Hampshire, belong to three magma series. The concordant Owls Head-Baker Pond complex, a member of the Oliverian magma series, apparently differentiated *in situ*. Regional deformation, probably late Devonian, granulated and crushed these rocks

* Introduced by C. P. Berkey.
** Published with permission of the Director, Geological Survey, U. S. Department of the Interior.
† Introduced by P. F. Kerr.

and developed an obscure secondary foliation across the primary igneous structure. The Bethlehem granodiorite-gneiss and probably the Kinsman quartz monzonite, members of the New Hampshire magma series, were intruded during the late stages of this deformation. The youngest member of this series, the Concord granite, was emplaced by stoping and is clearly post-tectonic. The Three Ponds gabbro distorts the surrounding granodiorite gneiss suggesting that it made its chamber by distension of its walls rather than by the process of cauldron subsidence which is characteristic of other igneous masses of the White Mountain magma series. Pegmatite, aplite, and late lamprophyre and quartz porphyry dikes cut the older plutons and enclosing schists.

Two grades of metamorphic rocks are recognized in the area. Intermediate-grade schists of the Ammonoosuc volcanics (Ordovician), Clough conglomerate and Fitch formation (Silurian), and Littleton formation (Devonian) crop out in the northwest part of the area. High-grade sillimanite-mica and quartz-mica schists of the Littleton formation are typical of the central and eastern parts. At the contact of the Bethlehem granodiorite gneiss, garnet-diopside contact rock has developed in the Fitch formation. Retrograde metamorphism of the sillimanite schists was noted adjacent to the Concord granite.

REGIONAL SYSTEMATIC JOINTING IN SLIGHTLY DEFORMED SEDIMENTARY ROCKS

BY JOHN M. PARKER, III *

Data on more than 6000 joints cutting the nearly horizontal Paleozoic strata of east, central, and southern New York and northern Pennsylvania reveal three regional joint sets of contrasting character. The local consistency of the joint pattern and a gradual regional swing are established. The lack of consistent relationships of the joints to other structures, especially the tracing of a "dip" set across the area into the "strike" position, indicates that the joints formed independently of, and earlier than, the folds, faults, and regional dip. The principal set is double, consisting of two conjugate shears intersecting at very acute angles (averaging 19 degrees); its pattern is radiating for the whole area. Theoretical analysis, confirmed by experimental tests, points to an origin by shearing under simultaneous compression and tension acting at right angles. The second set is single and lies perpendicular to the first, thus having a concentric pattern; it originated from tension. These two sets constitute a system of simultaneously formed fractures. The minor set maintains a constant position for the entire area; it probably is tensional but originated under doubtful circumstances, perhaps at a different time.

STRUCTURE AND PETROLOGY OF BOXELDER LACCOLITH, BEARPAW MOUNTAINS, MONTANA

BY WILLIAM T. PECORA†

A partly eroded laccolith of the Shonkin Sag type about 450 feet thick and 2 miles across forms a prominent flat-topped butte a few miles east of Boxelder, Montana. An upper layer of cliff-forming syenite about 120 feet thick grades downward to a coarse, friable shonkinite about 175 feet thick. Below this is a cliff-forming shonkinite about 40 feet thick and a friable, ribboned shonkinite about 50 feet thick, which has horizontal layers of syenite. The layers (ribbons) of syenite

* Introduced by C. M. Nevin.
† Introduced by Esper S. Larsen.

are thin and closely spaced near the base of the laccolith and become thicker and more widely spaced upward. Narrow irregular dikes of aplitic syenite cut the syenite and shonkinite. The coarse, friable shonkinite contains syenitic segregations.

Qualitatively, the rocks are much alike mineralogically. The shonkinite contains augite, olivine, biotite, sanidine, plagioclase, and analcime. The syenites lack olivine and contain aegirite. The aplitic syenite lacks plagioclase.

The main part of the laccolith is believed to have been injected as a shonkinitic magma and to have differentiated in place by crystal settling to form the upper syenite and most of the underlying shonkinite. The ribbons of syenite and the dikes of aplitic syenite were formed by local segregations of the residual liquid from the crystallizing shonkinite. When the first magma had largely crystallized, a second injection of magma formed the brim shonkinite.

ARCHEAN SEDIMENTATION

BY F. J. PETTIJOHN

The Archean sediments of the Canadian Shield are mainly graywacke. Much conglomerate, a little slate, and still less iron-bearing formation are also present. Excessive thickness, especially the thick conglomerates, abundance of graded bedding, rarity of cross-bedding, and absence of ripple mark, the graywacke or polymictic nature of the arenaceous beds, the absence of true quartzites and limestones, and the association with greenstones and tuffs are the earmarks of the geosynclinal facies. The sediments are much like the rapidly accumulated "flysch" sediments of later eras.

The petrology of the sediments of any age is more affected by the tectonic movements than by any other environmental factor. Whether the deposit is marine or continental is of less significance than whether it is orogenic or epeirogenic. Deep erosion leaves only the axial portion of Archean geosynclines and hence only orogenic sediments. In this fact is found an explanation of the petrographic similarity of all early pre-Cambrian sediments regardless of age (so-called Timiskaming type) and of the differences between these sediments and those of most of the Huronian (Huronian type) and later periods.

CALICHE KARST

BY W. ARMSTRONG PRICE

Distinctive features of the caliche karst arise from the jointless, noncavernous nature of caliche blankets, their thinness (2 to 50 feet), and the dry climatic regime of their origin and occurrence, with deep (25 to 350+ feet) water tables and drifting dune fields. During humid periods of the Quaternary climatic cycles, in places, dendritic stream systems trenched caliche-covered plateaus, solution basins filled with concretionary pond tufas, or were mantled by "algal limestones" of extensive lakes. Thin tufaceous crusts have indurated most caliche surfaces.

Slump has locally formed exaggerated, induced karst topography above solution cavities in buried strata. The normal karst begins in soil having pre-caliche stages of "soil lime" or in re-excavated caliche. The karst is patterned by antecedent topography, commonly of wasting dune fields with long, narrow swales. Basins (dolines) are broad, shallow (maximum 50 feet), smooth-sided, and soil-lined, with central playa ponds. A youthful stage is known from Llano Estacado of New Mexico and Texas and Reynosa Cuesta of southern Texas. Collapse phenomena and deflation of leached subblanket strata characterize a mature karst in Arabian Sum-

man. Strong eolian streamlining of wind-oriented, interbasin caliche remnants, and inversion of dendritic stream systems, with active and severed stream beds on caliche ridges, are striking features. The ridges represent low-level cementations of porous bed debris formed above deep water tables. Mesas capped by plateau-blanket caliches, usually descended into basal gravels, represent old age residuals (hums). Karst is reported absent on extensive caliche-blanketed plains near mountains, possibly explained by eolian mantle and erosion of caliche.

ORIGIN OF CALICHE

BY W. ARMSTRONG PRICE

World-wide climatic, soils, geomorphologic, and water-table data summarized in recent treatises establish the soil theory of caliche origin as modified by reclassification of caliche and other surficial, dry-climate mineral deposits according to geomorphic occurrence and geologic age.

Caliche is the end-product in well-drained, well-developed soils of the process of "soil-lime" accumulation. Concentration occurs well above water table in lower soil zones and in weathered or porous parent materials through "normal" soil processes of dry climates, where rates of weathering, soil development, and soil erosion are balanced. A karst (solution) topography develops in uneroded soil lime and caliche.

Plateau-blanket caliche of soil origin and outcrop-cementation caliche are recognized. The former, as far as known, occurs on elevated pre-mid-Pleistocene erosional and depositional surfaces of low relief and slope. The latter are in part younger and post-erosional. Their cementing solutions may be downward-percolating soil waters or water mineralized by flowing through caliche. Desert alkalies, nitrate "caliche," and other evaporites in soil fit the former capillary-evaporational hypothesis of caliche, being deposited at water-table outcrops. Desert crusts geomorphologically resemble caliche but may differ from it in origin. Lichens deposit some, at least, of the desert varnishes. Surface indurations of caliche and tufas, including oölites, pisolites, and "algal limestones" found with caliche, were probably formed by evaporation or plant agency on moist surfaces and in lakes of humid periods.

QUATERNARY GEOLOGY OF JUNE LAKE DISTRICT, CALIFORNIA

BY WILLIAM C. PUTNAM

The region about June Lake in the east-central Sierra Nevada provides an unusually complete Pleistocene record. Three glacial stages are represented. Volcanic activity dominated the interglacial stages. The sequence of events from youngest to oldest is as follows:

Stratigraphic unit	Event
Mono Craters obsidian	Eruption of obsidian domes and short, steep-walled flows.
Tioga terminal and lateral moraines	Renewed glaciation in previously excavated glacial troughs.
June Lake basalt	Basalt flow from small cinder cone in floor of June Lake glacial trough.
Tahoe lateral moraines	Glaciation and enlargement of pre-existing stream canyons.
Bishop tuff	Widespread eruption of rhyolitic ash.
Sherwin till.	Extensive glaciation of the eastern Sierra Nevada.

Deformation has been active throughout this history and has continued into the Recent. Faults cut the Tioga and Tahoe moraines. Two high-level shore lines of Mono Lake crossing the area at altitudes of 7160 and 7060 feet correlate with the Tahoe and Tioga glacial stages respectively.

Normal stream and glacial erosion controlled by structure carved the horseshoe-shaped valley occupied by June, Gull, Silver, and Grant lakes. It is not an abandoned meander as recently suggested.

IGNEOUS ROCKS OF THE COPPLE CROWN-MERRYMEETING LAKE AREA OF NEW HAMPSHIRE

BY ALONZO QUINN

The Copple Crown-Merrymeeting Lake area, like several other small areas in central New Hampshire, has considerable variety of rocks grouped together. Rock types here include, from oldest to youngest, felsite, diorite-gabbro, diorite, granite, quartz porphyry, and several dike rocks. Petrographically, they are related to the rocks of the White Mountain magma series of possible Carboniferous age. The variety of rock types indicates considerable differentiation of this magma.

The felsite may be extrusive, but the other rocks are intrusive. The intrusions cut sharply across the foliation and the contacts of the older rocks and are mainly in round or oval bodies. These relationships indicate a method of intrusion similar to that in near-by areas where ring-dikes and pluglike intrusions were formed.

RELATION OF TUSCALOOSA FORMATION OF WESTERN KENTUCKY TO A PRE-EXISTING WEATHERED TERRAIN

BY ROGER F. RHOADES*

The Tuscaloosa formation in western Kentucky, deposited at the extreme northern end of the upper Cretaceous Mississippi Embayment, is almost wholly a loose chert gravel in a matrix of white and gray clay.

The gravel was derived from the chert-bearing limestones of Mississippian Meremac and Osage groups. Roberts noted that these limestones exposed in a belt only about 20 miles wide—and narrower in upper Cretaceous time—indicate comparatively local derivation of the gravels. He also suggested that the Tuscaloosa formation in this region was at least in part the result of shoreline deposition.

The Pennsylvanian-upper Cretaceous hiatus was characterized by erosion which, just preceding the encroachment of the upper Cretaceous sea, had reduced the terrain to one of moderate or slight relief on which weathering had produced a mantle of residual chert and clay. Upon this surface, the encroaching sea reworked the chert and clay, rounding the chert and depositing gravel of varying thickness; much of the residual clay originally associated with the residual chert blocks was incorporated to make the matrix. The gravel was therefore formed without significant transportation but with extensive reworking *in situ*.

Residual chert and clay dating from this pre-Tuscaloosa period of weathering exist as irregular and discontinuous accumulations lying between the Tuscaloosa formation and the underlying undecomposed limestones; in many places the reworking of the residual material by the encroaching sea affected only the upper portions of the weathered regolith, and the gravels so formed served as a protective blanket over the unreworked chert and clay.

* Introduced by Edwin C. Eckel.

PHYSIOGRAPHIC SETTING OF NITRATE DEPOSITS OF TARAPACÁ, CHILE: ITS BEARING ON PROBLEM OF ORIGIN

BY JOHN L. RICH

A series of aerial photographs reveals the broader physiographic setting of the nitrate deposits. An old-age surface of a former mountain mass of complex structure—the Coast Range—dips eastward beneath the flat alluviated floor of the Longitudinal Depression between the Coast Range and the Andes. Great alluvial fans from the Andes extend far across the depression and, perhaps aided by recent crustal movements, explain why the lowest parts of the depression—now occupied by several large salt flats or salars—are along its west side. Along much of its length the old-age surface of the Coast Range dips directly beneath the salars.

The nitrate deposits lie mainly on the lower slopes of this surface, extending from the edge of the salars back for a distance of a few hundred yards to 1 or 2 miles and up to elevations of 100 or 200 feet above the salars. Locally, deposits are several miles back from and several hundred feet above the salars. "Islands" of the old-age surface projecting above the salars may be completely covered with nitrate workings.

Singewald and Miller's theory of the localization of the deposits by efflorescence from the ground water of the salars seems difficult to apply to some of the more distant and higher deposits, while Whitehead's theory of derivation from weathering of the bedrock and concentration by ground water seems inadequate to account for the deposits that completely mantle "islands" in the salars.

NEPHRITE JADE FROM MONTEREY COUNTY, CALIFORNIA

BY AUSTIN F. ROGERS

Nephrite jade of fair quality suitable for cutting and polishing has recently been discovered in Monterey County, California.

The nephrite ranges from light greenish gray to black; the best material is dark American green (Ridgway). It is identified as nephrite by optical tests, specific gravity, and a quantitative chemical analysis. The nephrite occurs in rolled pebbles and boulders of various sizes whose weights range from less than a gram to a maximum of over 60 Kg. It is also found in place in serpentine in a region of typical Franciscan rocks.

The locality is along the Coast in the southern part of Monterey County somewhere between Point Sur and the Salmon Creek Ranger Station and in the extreme western part of the Santa Lucia Range.

PETROFABRIC DETERMINATION OF QUARTZ GRAIN ORIENTATION IN SEDIMENTS*

BY RICHARDS A. ROWLAND†

A method has been developed whereby quartz grains are measured individually so that the measurements can be applied to quartz optic axis diagrams from oriented thin sections in order to interpret the fabric in terms of grain shape.

The angle between the pole to the greatest cross-sectional area and the optic axis, and the angle between the longest dimension and the optic axis of individual quartz grains taken from three channel sandstones and one shale of the lower Pennsylvanian of Illinois were measured on a universal stage. A statistical analysis of these data shows that the most frequent positions of the greatest cross-sectional area lie parallel

* Published by permission of the Chief, Illinois State Geological Survey.
† Introduced by R. E. Grim.

to the unit rhombohedron and the prism. These positions can be correlated with the differential hardness of quartz and are similar to positions obtained in pressure experiments.

Quartz and mica fabrics were measured from oriented thin sections cut adjacent to the spot from which the grains were taken. The maxima of the quartz fabrics were plotted on the surface of a sphere. About the centers of these maxima, circles were drawn whose radii were equal to the chord length of the statistical angles determined from individual grains. From the intersections of these circles with one another the most probable spatial position of the greatest cross-sectional area and longest dimension was determined. A comparison of these results with the mica diagrams of the same specimens makes it possible to draw certain conclusions concerning the controlling current at the time of deposition.

CHEYENNE MOUNTAIN OVERTHRUST, COLORADO

BY CHALMER J. ROY*

The presence of major faults along the eastern front of the Rocky Mountains in Colorado has long been recognized. The literature contains description of both normal and thrust faults, but the importance of the latter has not been fully realized.

The Ute Pass fault, described by Finlay in the Colorado Springs Folio and considered by him to be a normal fault, has been found to be a thrust fault. The fault has been traced from just south of Little Fountain Creek to a point near Manitou, a distance of about 15 miles. Throughout this distance the pre-Cambrian rocks have been thrust eastward over the younger sedimentary rocks.

The fault plane strikes in a general northerly direction ranging from N15E to N40W and dips westerly from 25 to 50 degrees. The minimum stratigraphic displacement is between 5000 and 6000 feet as indicated by outcrops where the granite rests on upper Niobrara shales. The horizontal displacement has a minimum value of about 8000 feet based on the same evidence.

Multiple faulting in which masses of Paleozoic sediments have been carried forward under the pre-Cambrian rocks and clastic dikes in the pre-Cambrian rocks are associated phenomena.

PETROLOGY OF THE PAWTUCKAWAY MOUNTAINS, NEW HAMPSHIRE

BY CHALMER J. ROY AND JACOB FREEDMAN†

The Pawtuckaway Mountains are in Deerfield and Nottingham townships, Rockingham County, in southeastern New Hampshire. Rocks of the Mississippian White Mountain magma series were intruded into the Winnepesaukee gneiss of the late Devonian New Hampshire magma series. The intrusion was a circular mass of gabbro, diabase, and diorite, which forced its way into the gneiss and bent foliation planes in the gneiss from the regional, northeast trend into partial parallelism with the igneous body. A foliation in the diabase and in one phase of the diorite body strikes parallel to the contact and dips inward. Injected into the more mafic rocks are bodies of fine-grained monzonite, of which the two largest bodies form a broken circle open to the southwest. A coarse-grained monzonite was later injected as the core of this arc, and a similar arc of coarse-grained monzonite surrounds the gabbro-diorite body on three sides and is also open to the southwest.

* Introduced by R. J. Russell.
† Introduced by M. P. Billings.

The Pawtuckaway Mountain rocks all differentiated at depth from one parent magma. A porphyritic gabbro solidified against the gneiss walls as intruded magma differentiated in place into four types of diorite. The biotite, hornblende, pyroxene, and feldspar in the monzonites differ only slightly from those in the diorites.

Aplitic, monzonitic, and lamprophyric dikes cut all the major rock types. The aplitic dikes cut the lamprophyric dikes, but the relationship of the monzonitic dikes to the other dikes is unknown.

CORES FROM GULF OF MEXICO OFF MISSISSIPPI DELTA

BY R. DANA RUSSELL

Twenty-four Piggot cores have been collected from the subaqueous portion of the delta and from the Gulf bottom out to a depth of 8000 feet. More than 200 samples from these cores have been analyzed for size distribution, calcium carbonate, and organic matter. Those from near shore are characterized by well-developed thin bedding and dark laminations, nearly equal amounts of silt and clay, and low calcium carbonate content. Those from deeper water are lighter, high in clay and in calcium carbonate, bedding is poor or absent, and Foraminifera are abundant.

Shepard's suggestion that the 34-fathom shoal northeast of the Mississippi submarine canyon may be a salt dome is supported by the evidence from two cores from the flank of this feature. Both the lithology and fauna of these cores indicate that the sediments were deposited under different conditions than now exist at this locality and probably are older than Recent. Ten-foot cores from the side and bottom of the submarine canyon consist entirely of Recent material. (Geological Society project.)

PALEONTOLOGICAL EVIDENCE REGARDING PLIOCENE-PLEISTOCENE BOUNDARY IN GREAT PLAINS

BY C. BERTRAND SCHULTZ AND THOMPSON M. STOUT*

The Pliocene and Pleistocene deposits of Nebraska have yielded abundant remains of fossil mammals. These show definite changes at successive geologic levels. Of particular significance in Great Plains stratigraphy is the important lithologic and faunal break in western Nebraska (and apparently throughout the Great Plains) between the latest Ogallala (Kimball and Sidney) sediments and the earliest "terrace" deposits (Broadwater and Lisco quarry level) of the present North Platte River.

The mammals found in the Kimball and Sidney sediments are distinctly Pliocene types, while the Broadwater-Lisco mammalian assemblage is more closely related to the middle Pleistocene quarry assemblage from Sheridan County than to the Pliocene mammals. Such Pliocene mammals as rhinoceroses, longirostrine mastodonts, antilocaprids (*Texoceros*), and advanced *Neohipparion*-like horses are typical of the Kimball and Sidney formations. At the Broadwater-Lisco quarry level, rhinoceroses are absent, and only the brevirostrine mastodonts *Stegomastodon* and *Mastodon* are known. The horses in the Broadwater-Lisco deposits have reached the *Equus* or advanced *Plesippus* stage. Such typical Pleistocene genera as *Mylodon, Megalonyx, Canis, Mephitis, Smilodon, Platygonus, Camelops, Tanupolama,* and *Hayoceros* are found in the same quarries. In addition, the presence of the *Castoroides*-like form *Procastoroides* and microtine rodents may be of importance. Several holdover Pliocene genera—*Borophagus* and *Nannippus?*—also occur, but holdover forms are to be expected, and undue importance should not be placed upon them.

* Introduced by A. L. Lugn.

Paleontological evidence serves to emphasize the importance of the lithologic break or disconformity which occurred at the end of Ogallala time and before the deposits at Broadwater and Lisco were formed.

ODESSA METEOR CRATER

BY E. H. SELLARDS

The Odessa meteor crater, located 10 miles west-southwest of Odessa, Ector County, Texas, was described by the writer in 1927. Excavations in progress at this crater were begun September 1, 1939 to make the crater an educational exhibit showing the effect of a meteor of considerable size striking the earth. The governmental agencies carrying on the excavations are the Works Project Administration, The University of Texas, and the County of Ector. The owners of the land have set aside 40 acres on which the crater is located for public purposes.

The crater is in the High Plains region where surface materials are sand and caliche underlain by Cretaceous limestone. As a result of the impact, the limestones originally at a depth of 15 or 20 feet have been lifted at the rim of the crater to or above plains level. The rock strata in the rim are highly tilted but flatten out quickly. Magnetometer survey, contributed by the Humble Oil and Refining Company, indicated the principal meteorite mass near the center of the crater, and bore holes encountered it at a depth of 164 feet. The meteorite, of which many pieces have been recovered in and around the crater, is iron of the octahedrite class.

PLEISTOCENE STONE IMAGES FROM TEXAS

BY E. H. SELLARDS

In 1929 a stone image was found in a gravel pit in Henderson County, Texas, at a depth of 16.5 feet, weight 98 pounds; a second in 1935, depth 12 feet, weight 62 pounds; a third in 1939, depth 22 feet, weight 135 pounds. The images were fashioned from concretionary sandstone boulders such as are found in this region. All three lay at approximately the same level near the base of the gravel, difference in depth being due to variation in overburden.

Within the Trinity River valley at this locality three well-defined terraces above the present flood plain are recognized. The highest and most extensively developed lies 60 to 70 feet above the present flood plain. The fossils from this terrace include several extinct species of mammals: elephant, mastodon, horse, camel, bison, tapir, beaver, peccary, armadillo, and sloth. From borings, excavations, and a comparative study of the terrace deposits and fossils, it is found that the gravel deposit containing the carved stones belongs to the highest of the three terraces and is of Pleistocene age.

PHASE PETROLOGY IN THE CORTLANDT COMPLEX, NEW YORK

BY S. J. SHAND

The Cortlandt complex, near Peekskill-on-Hudson, is formed of rocks that range from peridotite and pyroxenite through norite to diorite. G. S. Rogers mapped 14 species of these rocks and added syenite and sodalite syenite to the list. Robert Balk made a structural survey of the complex and showed it to be a funnel-shaped pluton within which three smaller funnels are developed. If these funnels mark channels through which magma ascended, the various species ought to be grouped more or less symmetrically about the funnels; yet Rogers' petrographic map shows

little correspondence with Balk's structural map. The explanation lies in the indefinite character of the indicated species, which grade into one another in every respect. Progress in understanding the complex requires the abandonment of "species petrology" in favor of "phase petrology" or the mapping of critical mineral phases. The most instructive phase is hornblende, which occurs in two forms, one primary and the other a poikilitic replacement of plagioclase and pyroxene. The first is confined to the marginal zone; the second is found all through the central region, extending far beyond the boundary of Rogers' enlarged hornblende field. The marginal zone of the norite is characterized by primary hornblende, by the frequent appearance of biotite in large poikilitic plates, and by the occasional development of poikilitic garnet. Syenite is just a local product of contamination, and the occurrence of sodalite syenite cannot be confirmed.

PERIGLACIAL INVOLUTIONS IN NORTHEASTERN ILLINOIS

BY ROBERT P. SHARP*

Beds of fluvioglacial sand, silt, and clay in the upper Illinois Valley are complexly deformed in a manner made unique by variously shaped masses of fine material intruded into sand. Rounded forms and downward intrusions predominate. Large-scale migration of fine material into the intrusive masses indicates considerable plasticity during deformation. Individual structures are termed involutions, and layers of deformed beds are called involution layers, an equivalent of the Brodelböden of German writers. At least in this area some beds of fine material are prerequisite for the development of involutions. Deformation has not been observed below a depth of 12 feet and may extend within 3 or 4 feet of the surface. Single involution layers are a few inches to 6 feet thick.

The lack of linear trends and the shape and distribution of intrusions show that involutions are not due to any of the well-known agents of deformation. They are attributed to intense differential freezing and thawing and to the development and melting of masses of ground ice. It is postulated that this occurred in a surficial layer above permanently frozen ground in an area peripheral to a glacier where periglacial (arctic) conditions prevailed. The involutions cannot be dated more precisely than late Cary or early Mankato, subdivisions of the Wisconsin glaciation.

The great number of successful periglacial studies in Europe should serve as a guide and stimulus to similar work in this virgin field in the United States.

STRATIGRAPHY AND STRUCTURE OF THE SOUTHERN RUBY MOUNTAINS, NEVADA

BY ROBERT P. SHARP†

The southern one-third of the Ruby Mountains contains one of the best exposed and most complete Paleozoic sections in northeastern Nevada. Simplicity of structure makes this section worthy of more detailed stratigraphic and paleontological study than attempted herein. A continuous sequence of 16,300 feet is subdivided as follows: Lower Cambrian 1400, Middle Cambrian 3100, Upper Cambrian 3500, Ordovician 3600, Silurian 1300, Devonian 3100, and Mississippian 300. Added to this is several thousand feet of Carboniferous beds, largely Pennsylvanian, which appear only in thrust sheets or fault blocks.

* Introduced by Kirk Bryan.
† Introduced by T. T. Quirke.

The internal structure of the range is a simple, eastward-dipping homocline complicated at the north end by igneous intrusions and at the south end by a mosaic of high-angle normal faults. Along the west-central flank is a low-angle, westward-dipping thrust upon which a minimum eastward displacement of 7 to 10 miles is highly probable. The thrusting can be dated only as post-Pennsylvanian and pre-Miocene.

The boundary structure is transitional from a westward-tilted horst, typical of the northern two-thirds of the range, to a simple westward-tilted fault block in the southernmost part. Late Pliocene or early Pleistocene fanglomerate west of the range is attributed to westward tilting of the mountain block caused by uplift along the east boundary fault.

Iowan-Wisconsin and later Wisconsin glaciers occupied the higher parts of the range and indicate a Pleistocene snow line at approximately 10,000 feet. (Geological Society project.)

INTERNAL HEAT OF THE EARTH

BY LOUIS B. SLICHTER

Problems of the earth's internal heat involve six important factors: (1) Gain of heat from radioactive sources throughout the interior, (2) Loss as measured by upward heat flux in the crust, (3) Original heat represented by temperature distribution when crust first solidified, (4) Value of thermal conductivity and change with depth, (5) Presence or absence of significant heat transport by convection currents in interior, (6) Large heat capacity, age, and thermal inertia of the earth.

(1) Recent measurements by Evans afford most reliable values. Used in computations of heat generated in Washington's earth-model they indicate total heat being generated is ten times greater than heat being lost. Reasons are presented indicating that estimates of heat-gain based on models may far exceed that actually occurring in the earth.

(2) Measurements by Ingersoll, Bullard, Benfield and others indicate mean value of heat loss in continental areas not far from 1.2×10^{-6} cal/cm^2/sec.

(3) Original gradient in the solidified earth is unknown because of fundamental difficulties. No satisfactory data are available from which to estimate change of melting point with pressure.

(4) Possibly thermal conductivity at depth differs significantly from surface values.

(5) Thermal convection velocities as small as one km./million years would transport 100 fold more heat than thermal conductivity. Convection currents may exist and maintain essentially adiabatic distribution at depth.

(6) Observed heat loss throughout earth's lifetime could be maintained with only small percentage decrease in internal temperature and without radioactive contributions. Also, large amounts of radioactivity might exist at depth without appreciable effect upon surface thermal gradients. Thermal evidence alone is utterly inadequate, but from independent studies in terrestrial magnetism, seismology, and in atomic theory some progress may result in problems of internal heat.

PERTHITE FROM CENTRAL NEW HAMPSHIRE

BY ALTHEA PAGE SMITH*

In the Mt. Chocorua area the post-lower Devonian intrusions of the White Mountain magma series contain four types of perthite. In type 1 albite-oligoclase is irregularly intergrown with alkali feldspar. Neither mineral follows planes of weakness in the other. One subtype forms borders on sodic oligoclase, the latter merging through increasingly sodic zones with the similarly oriented albite-oligoclase of the intergrowth. The latter is complex, containing patches of microperthite of type 2 within

* Introduced by M. P. Billings.

much of its homogeneous orthoclase. Proportions of albite-oligoclase and alkali feldspar vary. The latter continued crystallizing after completion of the intergrowth. Perthite of type 1 is believed to be of simultaneous, but not eutectic, crystallization.

Microperthite of type 2 forms borders on and patches within feldspar intergrowth of type 1. Type 2 consists of albite in narrow, even-spaced, parallel plane lamellae in orthoclase. The regularity of intergrowth suggests exsolution.

In type 3, microperthite of type 2 contains albite dikelets which follow and widen planes of exsolution and, rarely, planes of cleavage. Part of this albite occupied open spaces, and part replaced orthoclase.

In perthite of type 4, microcline is partially replaced by irregular blebs of albite. Rare euhedral grains of the latter suggest that this perthitization occurred as early as the deuteric, or interstitial, stage.

DUNE FORM AND WIND DIRECTION ALONG SOUTHERN SHORE OF LAKE MICHIGAN

BY H. T. U. SMITH

Four main types of dunes occur in the lake-border zone and record the directions of effective sand-moving winds, both past and present:

(1) Linear shore-dune ridges. These parallel both modern and ancient shore lines and indicate onshore winds of intermediate compass direction.

(2) "Blowouts." Active secondary blowouts transect the shore dunes at many places. Where protected from lateral winds by topography and forest, the direction of sand movement in these blowouts is essentially perpendicular to the shore line. Where unprotected, however, as in many of the larger blowouts, an easterly component of sand movement is observed and in some places is dominant, thus indicating the strength of westerly winds.

(3) Fork-shaped, U-shaped, and V-shaped dunes—hitherto unrecognized in the area—occur between the dune belt of the present shore and the Calumet shore line and are unrelated to shoreline topography. These all point eastward and testify to the former prevalence of westerly winds.

(4) Barchans—heretofore undescribed in the area. A few isolated and long-stable dunes of this type occur above the Calumet shore line. The lee slopes dip to the east, indicating movement by westerly winds, probably at a time dating back to the Lake Chicago stage.

The evidence of dune forms thus indicates that the prevailing winds of early postglacial time were essentially similar to those of the present.

FOUR-PHASE VOLCANISM IN HAWAII*

BY HAROLD T. STEARNS

Youthful phase.—Rapid outpouring of highly fluid primitive basalts forming a shield-shaped dome of thin sheets from two major rifts and one minor rift and from a small crater at their intersection. Olivine-bearing basalts predominate, and pyroxene phenocrysts are scarce. Few cinder cones are formed, the usual vent being a fissure bordered by spatter or a vent concealed by a mound of pahoehoe. All Hawaiian volcanoes have passed through this stage.

Mature phase.—Gradual collapse over the vent areas of the volcano forming a caldera on the summit and shallow grabens along the major rifts. The lavas pooled in the closed fault basins are massive and differ only in physical appearance from the pre-caldera lavas. The highest part of the caldera wall usually bounds the segment between the two rift zones intersecting at an obtuse angle. Generally the slope seaward of this wall is not flooded with lavas, and the streams and the sea erode it.

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This leads to two distinct physiographic stages in the deeply eroded domes. Kilauea and Lanai are in this phase.

Old-age phase.—Obliteration in part or in whole of the caldera and grabens by the volume of the filling lavas exceeding the amount of the collapse. The time interval between eruptions grows progressively longer, and the composition of the lavas may change slowly or abruptly toward more feldspathic lavas. Trachytes, andesites, or closely related rocks are laid down in thick sheets. Vitric tuff beds increase in number and in thickness, and plug domes may be formed. The more basic lavas in this phase usually carry large phenocrysts of one or more of the following minerals—pyroxene, olivine, and feldspar. The dome steepens and becomes studded with cones. Some of the vents lie outside the rift zones. Local erosional unconformities are found between some of the flows. Hualalai, Mauna Kea, Kohala, and possibly West Molokai are in this phase.

Rejuvenated phase.—Extrusion of ultrabasic lavas carrying nephelite or melilite or both and also basalts with or without pyroxene, feldspar, and olivine phenocrysts. They usually follow a long erosion cycle; hence are chiefly unconformable on all earlier lavas. Cognate inclusions are common. Widespread vitric or crystal-lithic-vitric tuffs may be common also, the latter resulting from phreatomagmatic explosions. Haleakala, East Molokai, Kahoolawe, Koolau, Waianae, Kauai, and probably Niihau are in this phase.

GEOLOGIC HISTORY OF GUAM

BY HAROLD T. STEARNS

Important events in the geologic history of Guam determined by a reconnaissance survey in 1937 are: (1) Building of a submarine volcano on the north-south Marianas rift. The first extrusions were chiefly basaltic pillow lavas from fissures a few feet wide. The fissured zone is now exposed as a dike complex. An intermittent explosive phase followed, during which more than 1000 feet of andesitic tuff and agglomerate with interstratified shales and marls containing Miocene Foraminifera was laid down. Fossils indicating shallow water were found in the agglomerate. (2) Cessation of volcanism. (3) Intense folding and overthrust faulting. (4) Deposition of shallow-water limestones. (5) Renewed faulting. (6) Emergence of 1300+ feet and subaerial erosion. The highest point of the island is 1334 feet above sea level and is capped with reef and detrital limestone. (7) Resubmergence during the Pleistocene to 700 feet above the present strand, during which time three islands existed surrounded with coral reef, one of which was Mount Santa Rosa, a near atoll. The Barrigada limestone was deposited which includes great quantities of reef talus and which now forms the northern plateau. (8) Complicated series of emergences and submergences, partly as a result of changing ocean levels, ending with Guam emerged 700 feet, to nearly its present level, but with the valley mouths partly drowned. Five distinct marine terraces were cut in the Barrigada limestone. (9) Emergence of 5 feet.

ORIGIN OF HALEAKALA CRATER, MAUI, HAWAII*

BY HAROLD T. STEARNS

A geologic map of Haleakala Crater, Maui Island, Hawaii, was finished by the writer in 1935 as part of the systematic geological investigation of the Hawaiian Islands by the United States Geological Survey, in co-operation with the Territory

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of Hawaii. The crater is 7 miles long and 2 miles wide. The highest point on the rim is 10,025 feet above sea level. Evidence is presented to support Cross' theory that this great "crater" is due chiefly, and perhaps entirely, to stream erosion by the recession of two great amphitheater-headed valleys, Keanae and Kaupo, from opposite sides of the mountain, instead of being due to either collapse, sliding away of a side of the cone, or explosion, as set forth by others. Kipahulu, Waihoi, and Manawainui valleys were likewise formed during this long erosion period. The ancient main rift zone crossed the summit and the heads of Keanae and Kaupo valleys. Renewed volcanic eruptions along this rift built large cinder cones and poured out voluminous flows that nearly masked the ancient divide between the two valleys and partly filled both to the sea. The depth of the fill probably exceeds 2000 feet at the valley heads. The lava flows displaced the drainage channels and caused the streams to undercut their valley walls, thereby widening their heads. Many of the late eruptions took place along fissures crossing the valley walls, thereby giving vent to flows that cascaded down the steep walls. A broad thick mud flow underlies the late lavas at the mouth of Kaupo Valley.

SEDIMENTATION IN GULF COAST EOCENE

BY H. B. STENZEL

The same sedimentary facies are repeated over and over again in the Eocene of the Gulf Coastal Plain. Brown, carbonaceous shales, for instance, occur in all formations, glauconite marls in all marine formations. The following is a common facies cycle: cross-bedded sands, well-bedded sands, silty-brown shale, fat brown shale, gray calcareous shale, glauconitic limestone, massive glauconitic marl, glauconitic brown shale, sandy-brown shale, well-bedded sands, and cross-bedded sands.

The thickness of a complete cycle is very much greater here than in the late Paleozoic of the western interior. Cycles are incomplete, and reversals occur in any stage. Although disconformities are most common at the base of the sands as in the late Paleozoic, they may occur at any level. Nearly all disconformities signify a small hiatus only, whose magnitude can generally be determined by several methods. A new method of evaluation of a hiatus is given, and new stratigraphic correlations are presented.

LOUISIANA-TEXAS GULF COAST AS A CLASSIC REGION IN STUDY OF SEDIMENTATION

BY L. W. STORM*

Sedimentary processes can be observed as in a laboratory in the delta and offshore regions of the Mississippi, a type area of such sedimentary environment. Related Recent and Pleistocene deposits can be compared with the contemporary ones. The Rio Grande and smaller streams provide a similar opportunity.

The older beds are exposed by outcrop and are cut by thousands of wells drilled for oil. Drillers' logs, drill cuttings and cores, and especially the electrical logs permit the correlation of studies of sedimentary processes active on the surface with studies of thick underlying deposits evidently accumulated by similar processes. Geophysics also contributes to the store of data.

* Introduced by W. Armstrong Price.

This field is important for its contributions to knowledge on: (1) Deltas and the concept of a Deltaic Coastal Plain, (2) subsidence under sedimentary load, (3) nature and sedimentary composition of continental shelves, and (4) glacial chronology and Pleistocene history.

PALEOZOIC PALEOGEOGRAPHY OF ARIZONA

BY ALEXANDER STOYANOW

In Arizona two major areas of deposition separated by Mazatzal Land were already established in the late pre-Cambrian time. First Paleozoic transgression from the northwest, starting possibly in the late Lower Cambrian and depositing Tapeats sandstone, reached central Arizona. The southern limit of Bright Angel shale and overlap of Muav limestone on the Tapeats indicate subsequent movements northward and southward in early Middle Cambrian time before the final withdrawal of the Cambrian sea from northern Arizona. In southeastern Arizona, likewise, only the earliest phase of Cambrian transgression reached Mazatzal Land: the northwestern boundaries of the late Middle Cambrian Troy, Santa Catalina, Cochise, and the Upper Cambrian Abrigo formations are all successively regressive southeastward. The Ordovician strata are known in Arizona only in the areas near New Mexico. Silurian and earlier Devonian deposits are present only near the extreme peripheral margins of Mazatzal Land beyond the limits of the State. Central-western Arizona was a positive element during early Paleozoic and earlier Devonian. The overlapping Upper Devonian transgression, also initiated from the northwest and southeast, deposited clastics around the central part of Mazatzal Land and was succeeded by deeper sea conditions in Mississippian time. The southeastern trough, regarded as a terminal arm of the Ouachita seaway, was the deeper of the two throughout the Upper Paleozoic. Withdrawal of seas from most of Arizona in late Mississippian time was followed by marked early Pennsylvanian transgression again introduced from the southeast and limited on the north by Mazatzal Land. Grading of the Manzano gypsiferous series and fossiliferous limestones into the Supai northward, and the distribution of Kaibab faunas, establish the relation of the southeastern trough to the northern area of Permian shallow-water marine and continental deposition.

LOGARITHMIC SCALE FOR ROCK DIAGRAMS

BY STERLING B. TALMAGE

A logarithmic percentage scale, for plotting the visible mineral content of igneous rocks, has proved a valuable teaching aid. The advantage lies in the fact that the logarithmic scale from 1 to 10 per cent is the same length as from 10 to 100 per cent. This permits minerals, of small quantity but of diagnostic significance, to be shown in a visual relation commensurate with their importance as classifying factors. Quantitative readings can be made from scale.

A circular diagram is used, with radii graduated on the logarithmic percentage scale. Each important mineral or mineral group has a designated sector. Mineral names are arranged circumferentially in parallel series, essentially according to Bowen's reaction principle, with higher-temperature minerals on the right and lower-temperature minerals on the left. Felsic minerals are all in the upper half, and mafic minerals in the lower half, of the diagram. Spaces are provided for generalizations and exceptions.

METHODS OF GEOLOGICAL SUBSURFACE STUDIES BY PETROLEUM GEOLOGISTS IN THE TEXAS-LOUISIANA COASTAL REGIONS

BY JOHN M. VETTER*

The Texas-Louisiana Gulf Coast is generally a monocline dipping coastward with Tertiary beds extending from the surface to the depth explored by the deepest wells (13,000'). Uplifts, including salt domes, and strike faults are the most prominent structural features. Since many of these are commercial oil fields, there are several thousand wells in which to study sedimentation and oil accumulation.

The importance of the subsurface geologist's work is explained by exhibits showing:—

(1) How the samples and drilling data of a well are interpreted by the geologist, and
(2) The inferred structures and lateral variation in sediments in this area.

GEOLOGICAL OBSERVATIONS IN THE LEBANON MOUNTAINS OF EASTERN ASIA

BY HAROLD E. VOKES

The Lebanon Mountains are a north- and south-trending range at the eastern end of the Mediterranean Sea. Investigations were conducted in this area during the past summer. Because of military restrictions it was not possible to work in the northern portion of the range, and the following observations are based on field work in the southern sections.

Although Tertiary rocks occur on their margins, the Lebanon Mountains are composed wholly of Upper Jurassic and Cretaceous strata. The Jurassic is represented by Kimmeridgian and (?) Portlandian deposits; the Cretaceous by the Neocomian, Aptian, Albian, and Cenomanian. Turonian and Senonian beds have been recognized on the flanks but are absent in the central portion of the range.

All the sediments except those of the Neocomian are of marine deposition. The latter are principally continental red sandstones with nodules of iron and lenses of lignite. Casts of plant stems are abundant, and dinosaur bones were found.

The range is bounded on both sides by prominent faults. A strong transverse fault zone runs east-west from the region of Beirut at least as far as Jebel Kenaise. To the north of this the range is essentially a horst of Jurassic with Cretaceous deposits forming the ridges and peaks; to the south it is a tilted block with the greater uplift on the western side, where the Jurassic crops out, and with Cretaceous deposits dipping gently off toward the east.

HYDROTHERMAL DEPOSITS IN THE SPECIMEN MOUNTAIN VOLCANICS, COLORADO

BY ERNEST E. WAHLSTROM †

Thrust-fault zones in the Specimen Mountain volcanics have provided channelways along which post-volcanic hydrothermal solutions moved. Deposition in the faults and replacement of adjacent favorable layers in pyroclastics and flows have produced extensive deposits of jasper and common opal. Associated with the deposits are numerous geodes containing onyx, agate, and platy calcite.

The mineralizing solutions probably came from depth and are related to the magma which was the source of the Specimen Mountain volcanics. However, considerable time elapsed between the extrusion of the volcanics and the deposition from solutions.

* Introduced by H. P. Bybee.
† Introduced by P. F. Kerr.

EXHIBIT OF STRATIGRAPHY AND STRUCTURAL FORMS OF TEXAS-LOUISIANA GULF COAST

BY PAUL WEAVER, CHAIRMAN, COMMITTEE OF A.A.P.G., HOUSTON GEOLOGICAL SOCIETY, SOUTH TEXAS GEOLOGICAL SOCIETY, AND SOUTH LOUISIANA GEOLOGICAL SOCIETY

Exhibit will consist of four parts:

(1) Historical review of growth of geological societies—Gulf Coast
(2) Outline of methods used in gathering data from drilling wells bearing on subsurface reservoir rock and stratigraphy
(2) Stratigraphic cross section of Gulf Coast and of individual oil field showing variation in sediments.
(4) Maps and cross section showing different types of oil-producing structures including salt domes, uplift, and fault fields. The distribution and shape of salt domes in a portion of the coast will be shown, as well as animated model indicating the theory of salt dome upbuilding. Micrographic-producing oil sands, Foraminifera together with actual cores from producing formations, cap rock, and salt.

It is hoped that the members of Geological Society of America in attendance will be interested especially in the stratigraphic cross sections which have been assembled by use of data obtained in the drilling of many wells, and which will be a total section of Tertiary in excess of 20,000 feet in thickness.

STREAM TERRACES IN TEXAS AND THEIR RELATION TO THE FORMATIONS OF THE GULF COASTAL PLAIN

BY A. W. WEEKS*

Stream terraces in the vicinity of Colorado River from Austin, Travis County, southeastward toward the Gulf of Mexico are mapped and described, and their correlation with the formations of the Gulf Coastal Plain is indicated. Beginning with the Willis formation, the recognized younger terraces from oldest to youngest are as follows: Upland, Uvalde, Asylum, Lissie (Capitol), Beaumont (Sixth Street), First Street, Riverview, and Sand Beach. Further studies may outline additional terrace levels between the Upland and the Uvalde where scattered gravel deposits are found.

Between Austin and the Gulf, cobbles in the bed of Colorado River are derived from local erosion of gravel deposits laid down by an earlier and larger river.

Streams cut their channels deep prior to the deposition of the Uvalde. The area along the coast where the Uvalde spread out above the Upland deposits, and the Asylum above the Uvalde, is now overlapped by younger sediments. Gravel deposits of Uvalde and younger age are now being mined along Colorado River in Fayette and Colorado counties and along the strike near other streams. The Asylum and Lissie terrace deposits contain much granitic material; the Uvalde includes many limestone pebbles beneath a leached upper surface, predominately chert, but little granitic material.

The growth of the present Colorado River delta—4 miles in 8 years—is pictured and described.

A profile from west-central Medina County southeastward to the Gulf of Mexico via Three Rivers and Corpus Christi shows the relation of the Uvalde of this region to the Willis and younger deposits in the vicinity of Nueces River.

* Introduced by Robert H. Cuyler.

KOOLAU BASALT SERIES, OAHU, HAWAII

BY CHESTER K. WENTWORTH AND HORACE WINCHELL

The Koolau Range forms the eastern, larger half of Oahu Island. It represents the maturely dissected Koolau lava dome, some 40 miles long and 20 miles wide, composed of basaltic lavas of the Koolau series, extruded from vents along a fissure zone at least 30 miles long which is now represented by a dike complex exposed in cliffs and valleys of the windward side of the range. Breccia occupying a small area in the windward foothills represents a transitory central Koolau vent: structural and morphological evidence indicates the dominance of rift-zone eruptions over central vent activity.

Most Koolau lava flow units are less than 10 feet thick. They lie essentially parallel to the elongate original dome surface, sloping 3 to 10 degrees radially outward. Both pahoehoe and aa flows are common, but no adequate record of the relative abundance is available. Petrographically, Koolau basalts vary only a little. They are mostly intergranular porphyries with tenth-millimeter pyroxene, plagioclase-ore groundmasses, and 2-millimeter phenocrysts of olivine, hypersthene, and plagioclase. Glass may constitute appreciable proportions of the groundmass; alkali feldspar may form small intergrain fillings. Accessory minerals are rare. Systematic variations have been sought through a stratigraphic range of 2000 feet and over the 30-mile length of the dome. Eight chemical analyses confirm the conclusion that there is very little variation throughout the length, breadth, and thickness of the visible Koolau series. Moreover, the analyses are similar and have similar variations to those of Kilauea and Mauna Loa rocks from Hawaii Island. The variations in chemical composition are mostly expressed in variable amounts, not kinds, of minerals.

MAGNETIC SURVEY OF WELLS CREEK BASIN, TENNESSEE

BY CHARLES W. WILSON, JR.

Wells Creek Basin, Stewart and Houston counties, Tennessee, has been described by Bucher as a "cryptovolcanic structure." The diameter of this intensely deformed and uplifted circular area is about 4½ miles. A magnetic survey was made of the surrounding area of 215 square miles with a vertical Askania magnetometer, and 162 readings were recorded. The absolute magnetic intensity within this area ranged from 52,525 to 53,000 gammas. One of the two most prominent features of the isogammal map drawn from these data is a belt 5 miles wide consisting of relatively low magnetic intensity, extending southeastward from Wells Creek basin and reaching the maximum "low" of the region surveyed, *i.e.*, 52,525 gammas, 8 miles southeast of the center of the basin. The other is an arcuate belt of high magnetic intensity extending from a point 8 miles south-southeast of Wells Creek basin northwestward to a point 4 miles west-northwest of the basin, being partially separated into two "highs" by a saddle 5 miles west-southwest of Wells Creek basin. The southern "high," which is centered 6 miles south-southwest of the basin, is the larger of the two, occupying a space larger than the intensely deformed area and "standing high" magnetically above all the surrounding region with the exception of the northern part of the same arcuate belt. No magnetic anomaly was found within the limits of the circular area of deformation and uplift. The belt of greatest magnetic variation occurs for a distance of 8 miles in a northwest-southeast direction along the southwestern flank of the "low" belt and the northeastern flank of the "high" that is

centered 6 miles south-southwest of Wells Creek basin. Here the intensity varies from 52,525 to 52,950 gammas within a distance of 3 miles.

The isogammal map described above is believed to show anomalous magnetic conditions in the general vicinity of Wells Creek basin. It is not known at the present time, however, whether such anomalous conditions have direct significance in regard to the origin of this "cryptovolcanic structure."

TRANS-CONTINENTAL GRAVITATIONAL AND MAGNETIC PROFILE OF NORTH AMERICA AND ITS RELATION TO GEOLOGIC STRUCTURE

BY GEORGE P. WOOLLARD*

A series of gravitational and magnetic observations was taken between Morro Bay, California, and Sea Bright, New Jersey. The route crossed the California Coast Ranges, the Sierra Nevada Mountains, Death Valley, the Great Salt Desert, the Rocky Mountains, the Denver Basin, the Great Plains, the Ozark Uplift, the Illinois Basin, the Cincinnati Arch, the Appalachian Mountains, the Triassic area of Pennsylvania and New Jersey, and the Atlantic Coastal Plain.

Observations were taken at intervals of approximately 5 miles, and the survey was checked for accumulative error against a network of base stations that had first been established at intervals of about 35 miles across the continent. Gravitational values were also checked against United States Coast and Geodetic Survey gravity pendulum stations.

The results of the survey show for the most part a marked agreement between the magnetic and gravitational anomalies. However, in some areas, as western Missouri, an inverse relationship was noted between these two sets of geophysical data. In some instances it is not possible to make a direct correlation with geologic data as to the possible significance of the anomalies, as for example in the Salina Basin where a marked gravitational and magnetic high occurs which is not related to any known basement structure. Conversely, the opposite condition was found to hold over the Nemeha Granite Ridge, where no marked indications were obtained in the geophysical data to indicate the presence of this subsurface geological feature.

For most of the large geologic structures, however, as the Illinois Basin and the Appalachian Mountain system, a direct correlation exists between the geophysical data and the geologic structures crossed. (Geological Society project.)

* Introduced by C. P. Berkey.

CORDILLERAN SECTION MEETING AT LOS ANGELES IN APRIL

PIEDMONTITE AND KYANITE FROM THE FRANCISCAN OF SANTA CATALINA ISLAND

BY EDGAR H. BAILEY*

A quartz schist with piedmontite and crossite on Santa Catalina Island is associated with glaucophane schist, lawsonite rock, quartz-albite schist, pillow lava, red chert, and serpentine. It is believed that the piedmontite schist belongs in the Franciscan group. The schist is believed to have been formed by the metamorphism of a manganiferous chert.

A green amphibole-kyanite-clinozoisite-corundum gneiss occurs associated with many types of hornblende, clinozoisite, plagioclase, and garnet gneisses and amphibolites. This series, occurring structurally above the glaucophanic rocks, may or may not be part of the Franciscan group.

REGIONAL CORRELATION OF STRUCTURAL ELEMENTS-PROBLEMS: WESTERN UNITED STATES

BY PAUL BILLINGSLEY AND AUGUSTUS LOCKE

Regional correlation involves identification and dating of structures within the scattered well-mapped areas and tracing these between areas. This divides into several problems: (1) Evolution of rocks. This is studied in the gradation between rocks of most diverse lithology such as shale-schist-gneiss-granite. This occurs along zones of motion and is maximum at foci of deformation. How common are gradations? Is granite an end product? Does motion cause the recrystallization? (2) Basement control of cover structures. Numerous structures are continuous from cover into basement. Correlative pairs are, for example, monocline over fault. In general, can basement structure be inferred from cover structures? Is basement motion the cause of both? (3) Evolutions of structural systems. Some are made by single stage motion never renewed. Many undergo one or more rejuvenations, and others are also complicated by intersecting structure systems. The recrystallization is proportional to the complexity. Eventually the rigidity acquired by recrystallization stops further motion. How general is this evolution? (4) Correlation of structures with sedimentary formations. Many clastic fans are tied to given structures such as thrust lobes. The fans along a major system, however, are successive rather than contemporaneous and indicate the "firing order" of the uplifts. Often clastic fans are the best clues to structures obliterated by the later deformations in rejuvenated systems.

In conclusion, the writers subdivide the western United States into six north-south panels, each topographically coherent, and indicate the structure systems within each in which the above problems have been particularly studied.

DESERT FLOODS IN ACTION

BY ELIOT BLACKWELDER

On the surface of the desert some years ago, during a severe storm, the writer had an exceptional opportunity to watch the action of flood streams descending the piedmont slope. The flood comprised a vast number of small interlacing channels in each of which the current was actively grading the surface. Active side cutting, with deposition as a minor process, was conspicuous. The bearing of these observations on the general origin of pediments and alluvial fans will be discussed.

*Introduced by A. O. Woodford.

CRYSTALLIZATION OF SALT AS A FACTOR IN ROCK WEATHERING

BY ELIOT BLACKWELDER

In certain desert situations brine drawn up by capillary attraction evaporates from rocks and boulders just above the ground surface. The crystallizing of the salt, like the better known frost action, disrupts rocks along joints, cleavage, and other lines of weakness. The most notable effects are seen on telegraph poles. Some of the circumstances governing the effectiveness of the process will be indicated.

GEOLOGY OF THE SAN JOAQUIN HILLS, ORANGE COUNTY, CALIFORNIA

BY FRANCIS D. BODE*

Rocks exposed in the San Joaquin Hills are of Tertiary and Pleistocene age. The total thickness of Tertiary rocks is nearly 5000 feet; the Pleistocene strata occur mainly as old terrace deposits and are not very thick. The Tertiary is represented almost entirely by Miocene rocks. The region was intensely faulted; this period of faulting is thought to have occurred in the Miocene. Dikes of basic lavas were intruded along, or near, the planes of many of the larger faults. While the age relationship between the faulting and the intrusion is not clear, it seems probable that the two events are, in part, contemporaneous. It is suggested that the present topography of the San Joaquin Hills has resulted from a gentle northward tilting of the area in Pleistocene and Recent time.

INTRA-CANYON LAVA FLOW OF THE LOWER GRANITE GORGE, GRAND CANYON

BY IAN CAMPBELL AND JOHN H. MAXSON*

In the Grand Canyon, over a distance of more than 85 miles from Toroweap Valley almost to Grand Wash Cliffs, are scattered exposures of an olivine basalt flow. The petrographic identity of the rocks and the accordance of upper surfaces with the river gradient, together with the lack of any other likely sources, point to a single source area for this lava, in the vicinity of Whitmore Wash and strongly suggest that all the intra-canyon exposures are remnants of a single great flow, perhaps 400 feet thick in the upper end, which temporarily dammed the river and prevented formation of the ellipsoidal structures which might otherwise have been expected. Small sills and dikes of basalt are exposed at intervals throughout this section of the canyon, but these are clearly earlier than the cutting of the present canyon, whereas the lava flow poured down the canyon at a much later date, when a stage of cutting very nearly coincident with the present had been attained. Subsequent erosion has removed the bulk of this lava, and remnants are found only in the most favored and protected positions.

TWO NEW PLIOCENE FORMATIONS IN CALIFORNIA

BY BRUCE L. CLARK

The purpose of this paper is to establish two new names in Pliocene sections of California. The first of these, the King City formation, is described for a series of deposits at the base of the Pliocene in the Salinas Valley area. The type area of this formation is to the east and southeast of King City between Peach Tree Valley

* Introduced by John P. Buwalda.

and Salinas Valley where it rests unconformably upon the basal complex. The King City formation is overlain by the Poncho Rico formation of R. D. Reed, the type section of which is on Poncho Rico Creek. The King City formation contains a fauna which has been previously referred to by the author as the *Astrodapsis antiselli* zone. The Poncho Rico formation which overlies it may be known as the *Astrodapsis peltoides* zone. Both of these zones may be represented in the type area of the Jacalitos formation.

The other formation is a new name for a series of continental beds, the type section of which is immediately to the west and southwest of Mt. Diablo. Previously these beds have been referred to incorrectly by the writer as the Orinda formation. This formation will be named the Green Valley formation, and it rests above marine beds of Lower Pliocene age, locally known as the Alamo formation. The Green Valley formation is overlain by lacustrine deposits which are locally known as the Tassajara formation.

SUBSURFACE STRUCTURE OF THE SAN JOAQUIN VALLEY, CALIFORNIA

BY WALTER A. ENGLISH*

During the last 5 years much structure mapping has been done by means of the seismograph in search of new oil fields in the San Joaquin Valley. While many of the data are still confidential, the broad features of the findings may be disclosed and are of considerable interest in bridging the gap between the Sierra Nevada type of structure on the east and the Coast Range structure on the west.

WELDED TUFF RESEMBLING VITROPHYRE AND PITCHSTONE AT BARE MOUNTAIN, NEVADA

BY STANLEY FEITLER†

The rocks composing the northern end of Bare Mountain are largely rhyolitic lapilli tuffs which are bedded in units from 50 to 300 feet and more thick. At the base of one of these units there is a layer resembling pitchstone; two units have a basal layer which appears to be an abnormal brown vitrophyre containing lapilli-sized fragments of gray perlite. Microscopic examination reveals that these rocks are made up of welded and flattened glass shards. These glasslike rocks grade upward into lithoidal rhyolitic lapilli tuff which corresponds closely to recent descriptions of rocks called "welded tuff" in California and "ignimbrites" in New Zealand.

The discovery of a glasslike rock composed of shards implies a more advanced stage in the process of welding.

BARRIER BEACH FORMATION AT LONG BEACH, CALIFORNIA

BY U. S. GRANT

At the mouth of the Los Angeles County Flood Control Channel at Long Beach, large volumes of stream-derived material are deposited during times of floods. For example, between May 1935 and May 1938 volumetric surveys indicate that 2,250,000 cubic yards of sediment were deposited between 8 feet above and 14 feet below mean sea level in an area at the flood control channel mouth extending from the east Long Beach breakwater easterly 3600 feet. Shore processes rapidly modify

* Introduced by W. S. W. Kew.
† Introduced by Siemon W. Muller.

the configuration of these deposits, sometimes rapidly developing offshore bars or barrier beaches. After the flood of March 2, 1938, a small offshore bar quickly formed whose development and growth were recorded in a series of aerial photographs. A study of these photographs shows that the manner of formation of these offshore bars is by wave scour and shoreward deposition of bottom material as explained by De Beaumont nearly 100 years ago and recently so well described and elucidated by D. W. Johnson. Shaler's theory also applies in the present case. Longshore drifting on the barrier beach causes growth on at least one end of the bar in the manner of spit growth. This may continue, ultimately producing a feature indistinguishable from a spit. (Geological Society project.)

SEISMICITY OF THE EARTH

BY BENO GUTENBERG AND CHARLES F. RICHTER

The relative seismicity of all parts of the earth for a limited period, using chiefly instrumental data, is discussed. The earth's surface consists of relatively inactive blocks separated by active zones of three groups.

(1) The circum-Pacific belt includes a large majority of shallow shocks, a still larger fraction of intermediate shocks, and all the very deep shocks. For shallow shocks the most active sectors are Japan, the Aleutian arc, western Mexico, Melanesia, and the Philippines. In Japan the belt divides into an East Indian and a Polynesian branch, the latter following the andesite line. Three loops surround outlying areas of probably Pacific structure: the Caribbean loop, the loop of the Southern Antilles (including South Georgia and the South Sandwich Islands), and a newly identified loop south and southwest of New Zealand. A branch passes near the Galapagos group and Easter Island along a zone of suspected continental structure.

(2) The Mediterranean and trans-Asiatic zone includes the remainder of the large shallow shocks and of the intermediate shocks. The epicenters fall along structural trend lines.

(3) Narrow belts of shallow shocks extend (a) through the Arctic and Atlantic oceans, following the mid-Atlantic Ridge, and (b) through the western Indian Ocean from Arabia into the Antarctic, probably connecting with the South Antillean loop. (c) A less active belt follows the African rift valleys.

The Pacific basin (except Hawaii) and the continental nuclear shields are nearly inactive. Between the stable shields and the active belts occasional large shocks occur. Small shocks apparently occur everywhere.

PRE-CAMBRIAN IGNEOUS COMPLEXES AND OROGENIES IN WESTERN NORTH AMERICA

BY NORMAN E. A. HINDS

Several cycles of igneous activity and at least three orogenic epochs are recorded in pre-Cambrian complexes of western North America. Oldest igneous rocks are schists derived chiefly from basic eruptives included in the dominantly metasedimentary, highly deformed basement complex. During deformation which followed accumulation of these most ancient strata, granitic, pegmatitic, and other magmas were emplaced. Existence of older granites is not yet demonstrated.

Much later are the Yeager greenstone and Red Rock rhyolite described by Wilson from central Arizona and the Irving greenstone in southwestern Colorado. A few rhyolite flows are interbedded with the still younger Needle Mountains group in southwestern Colorado and the Mazatzal quartzite in central Arizona. Other

probably contemporaneous igneous complexes are known. After deposition of the Needle Mountains and Mazatzal sediments, granite was intruded during folding.

Injected during deposition of the latest pre-Cambrian Belt series, the Grand Canyon series in northern Arizona, the Apache group in southern Arizona, and an unnamed sequence in southeastern California were many dikes and sills chiefly of diabase. Flows of basalt were erupted probably at the same time.

Of the three orogenic epochs now recognized, most important is the Arizonan which deformed strata of the basement complex; probably this orogeny took place at somewhat different times in different regions. Compression was intense, and, together with invading salic magmas, metamorphosed strata were affected. The much later Mazatzal orogeny, which followed deposition of the Needle Mountains and Mazatzal sediments, was local and less intense. The Grand Canyon orogeny mildly folded the latest pre-Cambrian strata in northern Arizona and southeastern California and was followed by block faulting.

CASCADE ANDESITES OF OREGON

BY EDWIN T. HODGE

The paper is a summary of studies made on extensive samples of the main bulk of the Cascan formation of the Cascade Mountains of Oregon. The rocks show many mineral combinations, yet all minerals show that they were once a part of a common magma, altered by incorporated rocks, that was moving toward a fixed mineral objective and stopped on this march at various places. Hence, the various mineral assemblages are only one frame in a cinemalike picture, the final scene of which would have shown all the rocks to be composed of pigeonite and labradorite. The effects of magma contamination, resorption, reaction, and arrested stages are found to be misleading when isolated flows or areas are examined. However, detailed optical studies on many hundreds of sections from many localities resolve the varied and complex results into a simple, straightforward change from a dacitic magma toward a basic andesite end product.

MODOC LAVA SURFACES

BY AUSTIN E. JONES*

Lava types noted in the field vary from the structurally strong and smooth-textured to weak and rough. In order are massive, scaly, and shelly† pahoehoe; slab and ropy lava; aa (in place), aa rubble, and block lava. The chief field difference between pahoehoe and aa is that the latter has a very disordered appearance, has sharp cuspoidal edges on the outer vesicles, with a degree of roughness that is greater than the vesicles. Massive pahoehoe is hummocky and thick in section. Scaly pahoehoe is of thin, small overlapping flow units. Shelly pahoehoe is thin and covers many small and medium-sized bubbles. It breaks easily into slab lava. Ropy lava is formed by the drag of mobile lava on plastic pahoehoe skin. In a stage of advanced cooling it may form furroughed† aa. Block lava, roughly cubical, is largely of fractured surfaces. Lava flows in the Modoc lava beds often end in ridges split along the top. In such cases no source of lateral pressure was noted. Probably the ridges first cracked in cooling. Possibly resurgence of the lava lifted

* Introduced by Charles A. Anderson.
† Term suggested by the writer.

and further split the ridges, with lava welling into the crack at times. Apparently "Pressure-Ridges" have been formed this way and were later surrounded by flow units. Some other term might be more descriptive, though it is suggested that internal pressure, rather than lateral pressure, has contributed to the origin.

DIVERSITY OF EPARCHEAN INTERVAL OVER CORDILLERA

BY CHARLES KEYES

As originally defined, the Eparchean Interval was a geological epoch supposed to cover the profound erosion on the Canadian Shield, before the Paleozoic sediments were deposited. Regarded as a single, simple, chronologic event, it proved in other regions to be a composite, of which the Canadian Shield phenomenon was merely the last of several peneplanations. The Eparchean Interval, or epoch, however, holds real kinship with subsequent events rather than with those connected with the basement complex. As such it can have no relation with the latter but is the directrix of a new major sedimental cycle. The eroded surface of the basement crystalline rocks no longer constitutes evidence of a specific chronologic epoch.

In the span it was thought to occupy on the Canadian Shield, there are in the Grand Canyon region half a dozen such intervals represented as pre-Paleozoic peneplanations. The multifaceted upper surface of the Archean basement complex of Arizona, especially, is described, illustrating the diversity of a geological age of what has long been called the Eparchean Interval.

Diastrophic analysis reveals that, instead of being a petty epoch, as premised for the Canadian Shield, it involved several such time spans, each one of which is a complete sedimental cycle, in which there was continental peneplanation, downsinking, and sedimentation of 4 or 5 miles, and raising and eroding of mountains as lofty and majestic as our Rockies of today. It is a time span as long as from the beginning of the Cambric to the present day. Geological time is immeasurably lengthened.

PHYSIOGRAPHY OF GREAT BASIN RANGES

BY CHARLES KEYES

Curious circumstance is it that out of the myriad Basin ranges there are so few on which normal fault lines, according to the Basin Range Structure hypothesis, blocking out the mountains are actually and unmistakably observed; that, of the few acclaimed observations of such, the evidences presented are so rarely convincing, and, indeed, they find better explanation in other ways; that the actual type range, upon which was chiefly founded the entire theory of Basin Range Structure, should turn out to be really an appanage of the folded mountain order; and that the necessary consequence of regional physiographic analysis should be so generally overlooked.

Despite the fact that the physiographic development of the Basin ranges has been heretofore so little regarded, it is perhaps not only fully as impressive as the tectonic history, but unquestionably surpasses it in orogenic importance. Tectonics are decipherable wholly within the Great Basin, physiographic impress largely from without, for within it has been virtually destroyed through profound deflation mainly. In recent geological times a mile or so of sediments has been deflated down to the present plains surface. The physiographic vicissitudes which the Great Basin must have gone through, all evidences of which are now obliterated within the region, are still preserved in the neighboring High Plateaus of Utah. Even the im-

perfectly finished Jurassic peneplanation still appears to be reflected in the Great Basin region. Fashioning of the present-day landscape may be, indeed, more dominantly physiographic than tectonic in character.

COLORADO RIVER SYSTEM IN THE GRAND CANYON

BY JOHN H. MAXSON*

The Archean, Algonkian, and Paleozoic systems of the Grand Canyon district are intricately broken by pre-Cambrian faults, on which displacement recurred. If the Colorado River originated in early Pleistocene time on exposed Permian strata of the plateaus, it might be expected that the course would reflect the structural pattern. If the river were developing during late Tertiary on an erosion surface cut on Mesozoic rocks, it might be expected that only the more important structures would influence the course. Only in the case of Reference fault does the channel follow a fault trace for over a mile. The channel is parallel to the Butte fault and to the east on the downthrown limb of the related East Kaibab monocline. The channel is parallel to and west of the Hurricane fault. Elsewhere the course of the Colorado is broadly winding and transects faults. These conditions suggest that the Colorado River existed as a powerful stream flowing westerly on a broad flood plain cut on relatively soft Mesozoic sediments during the later Tertiary. Rejuvenation by lowering of the effective base level to the west or by regional uplift or tilting perhaps accompanied by climatic change could explain entrenchment, canyon cutting, and plateau stripping.

The subsequent streams of the Grand Canyon faithfully reflect structural lineaments. These lineaments form a network oriented northeast-southwest and northwest-southeast. The northwest system is responsible for the broad amphitheaters at the heads of northeast-southwest insequent and structurally controlled tributaries. Examples are the Grapevine, Cremation, Ottoman, Hindu, Shinumo, and Tapeats amphitheaters.

MELANITE-NEPHELINE SYENITE FROM THE PANAMINT RANGE, CALIFORNIA

BY JAMES F. MC ALLISTER†

Coarse, leucocratic melanite-nepheline syenite occurs at the contact of one of the small, numerous, irregular intrusions of alkalic syenites which cut Paleozoic dolomites near Tin Mountain in the northern part of the Panamint Range. Constituents in order of abundance are microperthite, albite, nepheline, melanite, biotite, aegirine-augite, and magnetite.

The associated igneous rocks are sodic alkalic syenites which occur in dikes and sills. They vary greatly in texture and proportion of light and dark minerals, but most are extremely leucocratic. The dominant mineral is microperthite. Orthoclase, albite, microcline, quartz, muscovite, aegirine-augite, augite, green hornblende, greenish-brown biotite, and melanite are also found. Aegirine and hastingsite are rarer. In the darker varieties sphene, apatite, and magnetite are abundant as accessories; colorless garnet and fluorite are rare. Euhedral nepheline altered to white mica and calcite is abundant in the groundmass of one porphyry.

* Introduced by John P. Buwalda.
† Introduced by A. C. Waters.

SOUTHERN CALIFORNIA RING DIKE

BY RICHARD MERRIAM*

The mapping of a small area of the Peninsular Range igneous complex in the south-central part of the Ramona quadrangle, San Diego County, California, shows the existence of a ring-shaped body of leucocratic tonalite approximately 8 miles in diameter with an average width of one mile.

The entire area within the ring is a melanocratic tonalite. With the exception of one small outcrop this rock is not present in the immediate vicinity outside the ring. Surrounding the leucocratic tonalite ring are schists, gabbro, and other tonalites, some of which are older and some younger than the central melanocratic tonalite, but all are older than the leucocratic tonalite. Concordant bodies of schist occur inside, outside, and within the ring.

Along the inner margin of the leucocratic tonalite are dark inclusions streaked parallel to and increasing in size and abundance toward the central melanocratic tonalite. Outward-dipping pegmatite dikes in the ring suggest a relative downward movement of the central mass. Flow lines, contacts, and schistosity appear approximately vertical, but exact observations are not possible.

Emplacement was probably chiefly by forceful injection of the inner tonalite, which may have been intruded as a boss, but ring-fracture stoping was probably dominant in the later tonalite intrusion. Assimilation and piecemeal stoping are considered to have been unimportant.

NEW DATA ON SOME PROBLEMS OF KEWEENAW POINT, LAKE SUPERIOR

BY ELLIS ROBERTS†

The copper-bearing sediments and flows of Keweenawan age, which underlie the northwest side of Keweenaw Point, form a conformable series which to the southeast has been thrust over the Cambrian Jacobsville sandstone. The stratigraphic correlation of the Freda sandstone, which lies at the top of the copper-bearing series, is uncertain, as is the definite dating of the period of copper mineralization.

Field work was conducted to the southeast of the main copper-bearing area with the hope of establishing (1) the date of the native copper mineralization; (2) the relations of the Freda and Jacobsville sandstones; and (3) the dates of deformation.

The existence of a pre-Jacobsville period of mineralization was established, but its correlation with the native copper mineralization to the northwest cannot be definitely established.

The Jacobsville sandstone rests unconformably upon Keweenawan flows; in an adjacent area, the Freda sandstone rests conformably on flows of the same character. Hence the Jacobsville sandstone is thought to be later than and unconformable to the Freda sandstone.

At one locality the Keweenawan flows are tilted and sheared while the overlying Jacobsville sandstone is not affected, thus proving the existence of a pre-Jacobsville, but post-Keweenawan, deformation. Elsewhere, the marked disturbances of Lower Paleozoic strata prove another period of deformation which is definitely post-Lower Paleozoic.

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* Introduced by C. A. Anderson.
† Introduced by John P. Buwalda.

ORE DEPOSIT CONTROLLED BY PRIMARY IGNEOUS STRUCTURES

BY ALEXANDER SMITH*

The auriferous quartz-pyrite veins of Porcher Island, British Columbia, occur in a quartz diorite satellite of the Coast Range batholith. Detailed mapping by Cloos methods showed that:

(1) The form of the intrusive was determined by a combination of the trend of the intruded schists and a series of strong shears lying at a high angle to the schistosity.

(2) The ore bodies within the intrusive lie along the axis of a well-defined, steeply plunging nose of flow layers.

The parallelism of this axis to the old shears suggests that the intrusive may have arisen along one of them. Slight post-intrusive movement, also paralleling these shears, resulted in a series of short fissures located along the axis of the flow structure of the intrusive but lying transverse to the axial plane. These later fissures, now occupied by the veins, were in part controlled by the earlier jointing which had, in turn, been controlled by the primary flow structures. They are strong where they parallel the flow layers on the nose of the structure but die out rapidly where they transgress the layers on the limbs.

It was formerly believed that the deposits occupied cooling cracks in the upper portion of the intrusive and therefore would not persist to depth. Cloos methods have shown they lie along the axis of the intrusive and that their present exposure is at a considerable depth below the roof. Therefore the deposits may have a much greater vertical range than originally believed.

MESOZOIC ANDEAN GEOSYNCLINE

BY CHARLES E. WEAVER

The Mesozoic formations exposed in the Cordilleras of western South America consist of over 15,000 feet of marine and continental shales, sandstones, limestones, and conglomerates together with contemporaneous lava flows and tuffs. These deposits vary greatly in thickness and lithology from the Caribbean region to Tierra del Fuego and in many areas are extremely folded, faulted, and cut by intrusive rocks. There is no stratigraphic section known throughout the length of the Cordilleras which represents a complete and uninterrupted sequence of deposition. Tectonic forces intermittently and differentially active during the Mesozoic caused the development of local structural basins along the course of the Andean zone of weakness within which terrestrial and marine sediments accumulated. The marine faunas largely represented by ammonites show a sequence of faunal zones corresponding closely to those of the Mediterranean and western European regions. However, at certain intervals during the Jurassic the Indo-Pacific faunal elements suddenly appeared. What kind of paleogeographical interpretation may explain these occasional intercalations of western Pacific faunas with those of prevailing western European biologic relations? There is no good evidence for the former existence of a continental land area where the Pacific Ocean now lies. A narrow elongate strip of land representing a former westward extension of the border of the continent may have existed which was disconnected temporarily by transverse straits when Indo-Pacific faunas were introduced into the troughs of the Andean geosyncline; the straits were closed when the western European faunal elements prevailed.

* Introduced by John P. Buwalda.

STUDY OF THE ABRIGO LIMESTONE

BY JOHN H. WIESE*

The Abrigo limestone, first described by Ransome in the Bisbee district, is exposed in southeastern Arizona immediately over the Bolsa quartzite; both are Cambrian.

Petrologic and paleontologic data show that the Abrigo limestone was deposited in the neritic zone of a warm sea, the calcite being derived mainly from calcareous shell fragments, but possibly in part precipitated chemically. Insoluble residues are mineralogically similar to the adjacent pre-Cambrian granite. Most of the formation consists of thin alternating layers of limestone and shale; a minor part is sandy or detrital limestone. Differential solution under pressure explains many of the irregularities in thickness of the alternating limestone and shale layers.

Dolomitization is widespread and is not directly related either to metamorphism or alteration of the unconsolidated ooze but is the work of magnesia-bearing solutions which originated on the sea floor and percolated downward. Metasomatic dolomite occurs as iron-stained rhombs that frequently show several stages of growth and have replaced the original carbonates. Original structures, such as breccias, worm burrowings, and clay balls, controlled dolomitization which was largely a function of permeability, as shown by a concentration of dolomite in the laminae which contain abundant clastic grains of quartz and feldspar. Some of the calcareous shell fragments have been replaced, and it is suggested that the altered shells were originally aragonite.

MECHANICS OF METAMORPHIC OROGENY

BY BAILEY WILLIS

Orogeny is herein attributed to pressure exerted by growing crystals in process of metamorphism in the base of the cover of a body of magma, the latter being regarded as due to heating of an earlier intrusive mass, cooled beneath the crust and reheated by its radioactive content. This postulate requires consideration of the persistent eruptive activity of the globe during the past 2,000,000,000 years and a theory of the earth as an eruptive planet, with a growing core heated by radioactivity, is suggested. Bubbles of magma, intruding the mantle from the core and rising through it, are thought to have become differentiated, during the long ascent, into the end products, chiefly basalt and granite, the discrete bodies of which make up the crust. A common form of a crustal segment is that of a rounded disc, emplaced by a voluminous eruption and frequently outlined by volcanoes or marginal uplifts. Component discs of continental masses exhibit complex structures due to repeated intrusions and their margins are frequently the loci of compressed mountain ranges. The young ranges of the globe are found in regions which are characterized by batholiths of late Mesozoic to Tertiary age and have been involved in the subsequent orogenic movements. It is inferred that they rose from a hot spot, which, though left relatively cool, has become reheated and is still molten. The out-thrusts of the crust around the site of the buried magma is attributed to elongation of crystals in a horizontal direction as a result of metamorphism of its cover.

This paper is restricted to a discussion of the mechanism which directs the stresses and of the influence of resistances upon the resulting deformation.

* Introduced by James Gilluly.

GEOLOGY AND QUICKSILVER DEPOSITS OF COSO HOT SPRINGS AREA

BY H. D. B. WILSON AND N. W. HENDRY*

Granitic rocks form the core of the Coso Range. In the Coso Hot Springs area the granitic basement is overlain by as much as 200 feet of Recent or Pleistocene rhyolitic flows, tuffs, and breccias. Extensive hot springs and fumaroles have altered the granite and volcanic materials to opal and clay. The hot springs and fumaroles near the town of Coso Hot Springs lie along the east side of a fault scarp in recent granitic alluvium. The acidic hot springs contain unusually large amounts of sulphates, iron, aluminum, and silica, and considerable clayey material is carried in suspension. The mercury deposits 2 miles west of Coso Hot Springs are in another area of hot springs and fumaroles, which, however, show no geometrical arrangement. The mercury is present as cinnabar intimately associated with sulphur and alum. The cinnabar occurs as irregular deposits of low-grade ore in the granite and in the volcanic breccia and along the contact between the granite and the breccia.

SECTION ACROSS COMMERCIAL QUARRY, CRESTMORE, CALIFORNIA

BY A. O. WOODFORD, R. A. CRIPPEN, AND K. B. GARNER

More than 90 minerals have now been found in the quarries and mine of the Riverside Cement Company at Crestmore, California. Most of the minerals have been found in the Commercial Quarry. A section across this quarry shows granodiorite, quartz monzonite porphyry, pegmatite dikes, crystalline limestone, and silicate contact rock. Most of the minerals found in the quarry can be placed definitely in this section. It is doubtful if more than one mineral zone or facies can be clearly distinguished in the contact rock. The quartz monzonite porphyry grades into pegmatite, and the fairly numerous pegmatite dikes and irregular pegmatitic patches are closely associated with the silicate contact rock.

TREANORITE, A NEW MINERAL FROM CRESTMORE, CALIFORNIA

BY A. O. WOODFORD, J. D. LAUDERMILK, AND EDGAR H. BAILEY

The name treanorite is proposed for a new mineral which occurs as black crystals in the pegmatites of the Commercial Quarry, Crestmore, Riverside County, California. Treanorite is probably monoclinic, and its composition and properties are similar to but not identical with those of allanite.

*Introduced by John P. Buwalda.

ABSTRACTS OF THE PALEONTOLOGICAL SOCIETY

DECEMBER MEETING AT AUSTIN

BIBLIOGRAPHIC AND FAUNAL INDEX OF PALEOZOIC PELMATOZOA

BY RAY S. BASSLER AND MARGARET W. MOODEY

This index is in fulfillment of the promise made to the late Dr. Frank Springer that after his collection of fossil echinoderms in the Smithsonian Institution was placed in accepted museum form a bibliographic index of its more important subphylum, the Paleozoic Pelmatozoa, was to be prepared for publication to aid future students of the subject. As the exact stratigraphic position of many species has never been recorded, special efforts were made to obtain this information from specialists and by study of the types, the results of which are reflected in the faunal lists.

KEY BRACHIOPOD FAUNAS IN THE CAMBRIAN OF MONTANA

BY W. CHARLES BELL

Four brachiopod faunas, one of which can be divided into two subfaunas, occur in the Cambrian rocks of central and southern Montana. The oldest Middle Cambrian fauna, characterized by *Westonia* and *Wimanella,* occurs in the Wolsey shale together with the trilobite genera *Glyphaspis* and *Zacanthoides.* Slightly younger, and occurring in the lower Meagher limestone, is a prolific fauna characterized by *Micromitra sculptilis.* The fauna is divisible into two subfaunas: the lower, characterized by *Nisusia* and a new species of *Prototreta,* is associated with the trilobite genus *Ehmania;* the upper, characterized by *Prototreta trapeza* and a new species of *Micromitra,* is associated with the trilobite genus *Bathyuriscus.* The oldest Upper Cambrian fauna, characterized by a new species of *Dicellomus,* occurs in the upper Park shale and lower Pilgrim limestone and is associated with the trilobite genera *Cedaria* and *Crepicephalus.* The Dry Creek shale and its partial equivalent, the Snowy Range formation, contain the youngest Upper Cambrian fauna, characterized by *Linnarssonella, Eoorthis, Huenella,* several species of *Billingsella,* and the trilobite genus *Conaspis.*

A somewhat different arrangement of the same faunal elements is present in northwestern Montana. The Gordon shale contains *Wimanella simplex* and species of *Acrothele* and *Iphidella. Westonia* is limited to the type Pagoda limestone, where it is again associated with *Glyphaspis.* The "Pagoda" limestone, underlying the Pentagon shale and characterized by the trilobite genus *Ehmania,* contains *Micromitra sculptilis* and *Nisusia.* The overlying Pentagon shale, characterized by the trilobite genus *Bathyuriscus,* contains *Micromitra sculptilis* and *Prototreta trapeza.*

BIBLIOGRAPHIC INDEX OF PERMIAN INVERTEBRATES

BY C. C. BRANSON

Permian (including Uralian) invertebrate species are analyzed in a bibliographic index now nearing completion. A total of 7621 species are listed. Distribution of species by larger groups and in dominant families is as follows:

Foraminifera	563	(Fusulinidae	360)
Porifera	120		
Anthozoa	357	(Clisiophyllidae	101)
Stromatoporoidea	20		
Blastoidea	40		

Crinoidea	317	(Poteriocrinidae	129)
Echinoidea	24		
Asteroidea	3		
Holothuroidea	8		
Brachiopoda	1649	(Productidae	377)
Bryozoa	233	(Fenestrellinidae	60)
Lamellibranchiata	941	(Pectinidae	199)
Gastropoda	488	(Pleurotomariidae	107)
Cephalopoda	607		
Amphineura	8		
Scaphopoda	16		
Annelida	23		
Trilobita	78		
Crustacea	217	(Ostracoda	167)
Insecta	753		
Myriapoda	42		
Arachnida	19		

The apparent proportion of species in the fauna is doubtless too large for the fusulinids, brachiopods, and cephalopods, for these groups have received the greater amount of attention from paleontologists.

NEW ORDOVICIAN CONODONT FAUNAS

BY E. B. BRANSON AND M. G. MEHL

South of Ada, Oklahoma, a section of Ordovician rocks ranging from Arbuckle to Viola in age has produced conodonts abundantly from four distinct zones, one in the McLish, two in the Bromide, and one at the base of the Viola. The McLish fauna is almost exclusively chirognathid of a distinctive type and does not carry into the Bromide. There are differences in the assemblages from the two Bromide zones but much less than between the highest of these and that of the zone at the base of the Viola. The latter is much like the fauna of the Plattin as developed in Missouri.

A large conodont fauna removed with acid from the Kimmswick of northeastern Missouri is intermediate between the fauna of the Plattin and that of the Maquoketa.

PROGRESS IN THE STUDY OF *ARCHIMEDES*

BY G. E. CONDRA

This is a report upon a study of *Archimedes* made by Condra and Elias. New species are described and the geologic range of the genus is extended. New species collected from the Pennsylvanian and Permian are described. *Helicopora* is classed with *Archimedes*. (Geological Society project.)

SOFT ANATOMY OF *BOTHRIOLEPIS CANADENSIS*

BY ROBERT H. DENISON

Sectioned specimens of the armored fish, *Bothriolepis canadensis*, from the Upper Devonian of Scaumenac Bay, Quebec, show the form and position of some of the soft organs, preserved due to differential filling by sediments. It is thought that only those organs are preserved which communicate with the exterior and thus could be filled with sediment prior to their decomposition. The alimentary tract is seen to be a relatively simple, straight tube with an expansion in the posterior part of the trunk having a spiral structure comparable to that of the spiral valve of elasmo-

branchs. Gills are indicated and are restricted to the head region. From the pharynx arise two large, paired, ventral sacs, extending posteriorly about one-third the length of the trunk. These are interpreted as lungs, a conclusion which seems plausible when we consider that *Bothriolepis* was a gnathostome and was living in close association with Dipnoi and Crossopterygii, both of which probably had developed lungs by the Upper Devonian. Paired structures protruding from the posterior end of the carapace have been interpreted by others as pelvic fins or frills but may have an excretory or reproductive function.

TERTIARY GRASSES AND OTHER HERBS FROM THE HIGH PLAINS

BY MAXIM K. ELIAS

Seeds of the late Tertiary prairie grasses are fairly common throughout the most arid parts of the Prairie States. The most common among these fossil seeds show close relation to the most typical modern prairie grass: the spear-grass or *Stipa*, which has world-wide distribution. The oldest known ancestor of this grass was found in the Harrison formation of lower Miocene in western Nebraska.

Another prairie grass, a millet (*Panicum*), and one of its kin (*Setaria*) appeared here only in the Pliocene, when the prairie was also invaded by numerous borage herbs, ancestors of modern *Lithospermum*, *Krynitzkia*, and *Lappula*, which are now also very common among the forbs of the plains.

The preservation of the protective covers of the fossil seeds is so nearly perfect that some fine morphologic details, previously undescribed for Stipeae, were for the first time detected on the fossil *Stipidium* and subsequently on some species of its living descendant, *Stipa*.

Comparative study of the fossil and living forms reveals evolutionary trends of the seeds of the prairie grasses. The rather small and generalized Miocene ancestor gave rise to greatly diversified Pliocene and Recent species. The seeds of these include small and very large, very slender and very stout forms, all of them variously adapted for protection against drought and for more efficient dispersal.

Abundance, good preservation, and rapid ecologic and evolutionary changes make grass seeds the best index fossils for subdivision of the continental late Tertiary rocks.

SUPERFAMILY DISCOSOROIDEA (NAUTILOIDEA)

BY ROUSSEAU H. FLOWER

Ontogeny shows that only two groups of early Paleozoic cephalopods are primitively cyrtochoantic. For one of these the new superfamily Discosoroidea is proposed. It differs from the other, the Actinoceroidea, in the very small apical end of the siphuncle, the continuous lining formed by siphonal deposits, the absence of a siphonal vascular system, and the prevailing breviconic form. Families and genera are summarized as follows:

Ruedemannoceratidae, new family, *Ruedemannoceras*, n. gen., type *Cyrtactinoceras boyci* Whitfield, subcircular brevicones, subcentral empty siphuncle, broadly expanded segments. This contains ancestral forms of the Chazyan.

Westonoceratidae Foerste and Teichert. Breviconic, exogastric, compressed, siphuncle small, ventral, containing segmental lining of two layers. *Westonoceras*, *Teichertoceras*, and possibly *Wilsonoceras*, Trenton-Richmond of Arctic region.

Cyrtogomphoceratidae new family. Compressed endogastric forms with large siphuncles containing continuous lining of several layers. *Cyrtogomphoceras* and

Landeroceras, Trenton-Richmond, Arctic region. Derived from Ruedemannoceratidae.

Discosoridae Teichert. Brevicones with rapidly expanded siphuncles containing heavy deposits simulating endocones. *Discosorus, Stokesoceras, Endodiscosorus, Kayoceras.* Derived from Cyrtogomphoceratidae. Richmond to Clinton.

Lowoceratidae new family. Longiconic cyrtocones, siphuncle relatively slender, containing deposits similar to those of the Discosoridae. *Lowoceras, Tyloceras;* Lower Silurian, Arctic fauna. From Discosoridae.

The group is apparently stenosiphonate and unrelated to the Actinoceroidea. There is at present no evidence to connect it closely with any other cephalopods. Additional forms, now being investigated, may extend the group as far as the Middle Devonian.

FORAMINIFERAL EVIDENCE FOR THE MIDWAY (PALEOCENE) AGE OF THE CANNONBALL MARINE BEDS IN NORTH DAKOTA

BY S. K. FOX, JR., AND R. J. ROSS, JR.

An analysis of 61 species of Foraminifera indicates Midway (Paleocene) age for the Cannonball beds of North Dakota. This supports recent evidences from paleobotany and vertebrate paleontology but is contrary to the former belief, based upon the large invertebrates, that the Cannonball was of late Cretaceous age.

The new foraminiferal evidence is as follows:

(1) The general aspect of the fauna is Tertiary; as in the Gulf Coast the relative strength of the Lagenidae and Rotaliidae over the Textulariidae and *Globigerina* is notable. Furthermore, such common Cretaceous genera as *Globotruncana* and *Guembelina* are absent.

(2) Many cannonball species and Texas Midway forms are identical or very closely related. Thirty-nine of the 61 Cannonball species are known elsewhere. Of these, 34 occur in the Midway, 19 in Late Cretaceous formations, and 22 in Gulf Coast formations younger than the Midway.

(3) Of the 34 Cannonball species which occur in the Midway, 12 have been known heretofore only from the Midway. These include such well-known forms as *Lenticulina pseudo-mammilligera* (Plummer) and *Valvulineria midwayensis* (Plummer). Only 1 Cannonball species has heretofore been restricted elsewhere to the Late Cretaceous. Furthermore, only 2 of the Cannonball species occurring also in post-Midway Tertiary formations have previously been limited to post-Midway beds.

(4) Fifteen Cannonball species are new. The majority of these are more closely related to Midway and to Wilcox (Eocene) forms than to Cretaceous species.

(5) Of the 7 Cannonball forms which have not been given specific designations, 4 are similar to Midway species, and none show Cretaceous relationships.

PLIOCENE EQUIDAE OF THE TEXAS GULF COASTAL PLAIN

BY JOSEPH T. GREGORY

The Goliad formation consists of nonmarine conglomeratic sands and associated clays. In Live Oak, Bee, and Goliad counties it has yielded the best collections of Pliocene vertebrates thus far obtained from the Texas Coastal Plain. Comparison of these fossils with well-known High Plains faunas suggests an early Pliocene (Clarendonian) age for the Goliad.

Five genera of horses have been obtained from these deposits. *Hypohippus* cf. *affinis* Leidy is represented by a single specimen; *Neohipparion* sp. aff. *N. coloradense* (Osborn) is fairly abundant; *Pliohippus* cf. *supremus* (Leidy) is rather rare; *Nannippus* cf. *retrusus* (Cope) and *Calippus francisi* (Hay) are most abundant. Molar teeth of *Calippus francisi* (Hay), originally placed in *Merychippus*, are as hypsodont as

those of *Calippus placidus* (Leidy) and *C. regulus* Johnston, with which they also agree in connected protocones, extremely simple enamel borders of fossettes, and small, high, slender crowns. The hypostylar groove or fossette is extremely variable. Lower molars are rather low crowned with metastylid—metaconid not widely separated. The size is consistently smaller than the associated *Nannippus*. Hay's paratype is not cospecific with the type and belongs to the *Nannippus* common in these deposits.

Similarities between the most primitive species of *Calippus* and *Nannippus* in variations of the hypostylar fossette or groove and the frequent partial or complete connection of protocone with protoloph in the earliest species of the latter suggest that both may have been derived from a late Miocene protohippine species of *Merychippus* in spite of the *Hipparion*-like character of advanced species of *Nannippus*.

NEW RECONSTRUCTION OF SKELETON OF *EUSTHENOPTERON* AND ITS BEARING ON EVOLUTION OF THE PAIRED FINS

BY WILLIAM K. GREGORY

The well-known restorations of *Eusthenopteron* by Whiteaves and Bryant, although embodying many important facts, did not show the skeleton as a whole. In the author's earlier reconstruction the body was somewhat too short in relation to depth, and there were other errors. A careful study of available material has resulted in a new restoration of the skeleton. A review of evidence leads to the suggestion that the *Eusthenopteron* pectoral limb skeleton has been derived from a tribasic type essentially similar to that of such early elasmobranchs as *Tristychius*.

RELATIONS OF PREAXIAL AND POSTAXIAL BORDERS IN PAIRED APPENDAGES OF RHIPIDIST FISHES AND THEIR BEARING ON ORIGIN OF TETRAPOD LIMBS

BY WILLIAM K. GREGORY AND H. C. RAVEN

An examination of all available material of *Eusthenopteron, Sauripterus,* and related types has shown: (1) that in the pectoral appendage of limb the preaxial border of the fin, characterized by the stiffer, thicker dermal rays and a straighter fin border, is directed ventro-laterally, whereas the postaxial border is directed dorso-medially; (2) that the bones of the metapterygial axis of the fin lie along its post-axial border close to the body and that this condition is directly homologous to that of fossil and recent selachians; (3) that the preaxial border of the fin is raised in *Polypterus, Ceratodus,* and other forms so that it is directed dorso-laterally, while the postaxial border, still close to the body, is directed ventro-medially; (4) that the distribution of spinal nerves to the muscles of the limb as figured by Braus, Romer, and Howell all lend support to the conclusion that the preaxial border of the fin of sharks and rhipidists is homologous with the radial border of the limb of tetrapods, and therefore the proximal bones in the fin of rhipidistian fishes can be homologized with the humerus, radius, and ulna of tetrapods.

An attempt is made by means of diagrams, models, and lantern slides to visualize the changes in the pectoral and pelvic limb skeleton during the transformation from rhipidist to tetrapod.

TEXAS FOSSIL FISHES

BY CURTIS J. HESSE

Fossil fishes are not common in the rocks of Texas. Shark teeth, fin spines, and fragments make up most of the fauna. Of the described specimens 2 are reported from

the Pennsylvanian, 21 from the Permian, 2 from the Triassic, 17 from the Cretaceous, and 10 from the Tertiary. Of the 54 specimens described from this State, 45 are determinable specifically. These are grouped as follows: Elasmobranchii, 15; Dipnoi, 8; Ganoidei, 16; Teleostei, 6. To this list we may now add a new ganoid and two new teleostes in the Mark Francis collection of fossil vertebrates at the Museum of the Agricultural and Mechanical College of Texas. (Geological Society project.)

CAMBRIAN *SKOLITHOS* AND *PLANOLITES* AT READING, PENNSYLVANIA

BY B. F. HOWELL

The perpendicular burrow usually called *Scolithus linearis*, which is common in the Lower Cambrian Hardyston and Chickies formations of southeastern Pennsylvania, was named by Haldeman, its original describer, as *Skolithos linearis*. Hall's change of spelling of the generic name to *Scolithus*, which has been followed by later authors, was contrary to article 19 of the International Rules of Zoological Nomenclature, and Haldeman's spelling should be used in future. Haldeman's original types of the species have been lost, and a neoholotype from the Hardyston at Reading, Pennsylvania, has therefore been chosen and placed in the Princeton University collection. The worm burrow, *Planolites montalto* (Simpson), the original types of which came from the Lower Cambrian Montalto sandstone of Pennsylvania and have been lost, has been discovered in the Hardyston at Reading, and a neoholotype from there has been chosen and placed in the Princeton collection. Descriptions and illustrations of these and other examples of these species will be published in the Bulletin of the Wagner Free Institute of Science of Philadelphia.

"*SCOLITHUS VERTICALIS*" HALL IS *MONOCRATERION CLINTONENSE* (JAMES)

BY B. F. HOWELL

The vertical burrows from the Devonian Portage beds of Portage, New York, to which Hall in 1843 gave the name *"Scolithus verticalis"*, are not conspecific with the burrows from the Silurian Medina rocks of New York which Hall called by that name in 1852. Hall's Medina burrows were recognized as a distinct species by James, who in 1892 proposed calling them *Scolithus clintonensis*. Burrows believed to be referable to James' species have been discovered in Clintonian Silurian rocks in Juniata County, Pennsylvania. These burrows have funnel-shaped apertures which make them so closely resemble the Swedish Lower Cambrian burrows named by Torell *Monocraterion tentaculatum* and the Pennsylvania Lower Ordovician burrows named by Prime *Monocraterion lesleyi* that it seems probable that James' species should be referred to Torell's genus and that it should be known as *Monocraterion clintonense* (James). If this generic reference is correct, the known stratigraphic range of *Monocraterion* is extended upward to the Middle Silurian.

CHECK LIST OF CALIFORNIA TERTIARY MARINE MOLLUSCA

BY A. MYRA KEEN AND HERDIS BENTSON

This is an objective index to the literature, alphabetically listing figured specimens of California pelecypods, gastropods, and scaphopods from Paleocene to Pliocene (up to but not including Lomita correlatives).

An effort has been made to keep insertions and interpretations clearly separate from author's statements; information not given in original publications but available

through research is bracketed. All stated localities have been checked against maps in an attempt to construe sections, townships, and ranges as well as formations; omissions of locality information have been supplied wherever possible from labels and field notebooks. The formula for each entry in the catalog is: name combination as cited by the author; author's name; date; reference; author's statement of formation; interpretation; author's statement of age (in quotation marks if there is disagreement); locality, in the following order: number, verbal description, construed location, quadrangle, county; cross references and remarks; present repository of figured material, with catalog number and notes on status of specimens. A species index enables students to trace the various generic allocations of species. Included also is a chart showing current concepts as to age-range of formations cited.

The list is divided into two sections—bivalves, comprising 232 genera and 950 species, and univalves, with 308 genera and 900 species. Approximately half these species occur in Eocene formations. Genera with the greatest number of species names are *Pecten, Arca,* and *Turritella.*

PALEOZOIC FAUNAS OF THE NEW RIVER BASIN

BY A. A. L. MATHEWS

The fossil faunas applicable to definite limitations to the formations which occur in the New River Basin under modern terminology are discussed. The accompanying chart correlates the formations with well-established units.

PENNSYLVANIAN BELLEROPHONTID GASTROPODS

BY RAYMOND C. MOORE

A molluscan fauna collected in north-central Kansas from the Deer Creek limestone of the Shawnee group, upper Pennsylvanian (Virgil), contains bellerophontid and other gastropods that show excellently the apertural characters and features of shell structure. Study of specimens of *Euphemites* indicates that the prismatic shell layer, secreted by an anterior border region of the mantle, is marked on the outer side by growth lines and covered by (1) a thin smooth layer formed by a backward reflection of the outer edge of the mantle, and partly by (2) a longitudinally ribbed inductura that is deposited by posterior and lateral parts of the mantle. The "obsolescence" of ridges on a portion of the last whorl of *Euphemites,* not previously explained, is seen to belong inherently both to old and young individuals. A new bellerophontid genus, represented by nearly all growth stages, is characterized by a series of paired tubular projections bordering the slit band. These hornlike structures are believed to mark the loci of incurrent streams of water that bathed the ctenidia. Mature specimens of this genus and of other bellerophontids in the collection show a cavity between the inductura and the surface of the preceding whorl.

GROWTH STAGES OF *SYMBATHOCRINUS*

BY RAYMOND C. MOORE AND JOHN D. EWERS

An outcrop of the Chappel limestone, of early Mississippian (Osage) age, on Colorado River at Marble Falls, Texas, has yielded many immature specimens of a species of *Symbathocrinus.* These are associated with a few mature examples. All the immature forms have a well-developed oral circlet, and very youthful specimens lack facets on some of the radials. Study of these fossils throws light on the

ontogeny of a group of inadunates that has not previously been investigated in this manner.

PERMIAN CORALS FROM NORTH AMERICA

BY RAYMOND C. MOORE AND RUSSELL M. JEFFORDS

A preliminary report on types of rugose corals from Permian rocks of western Texas and the northern Mid-continent region is presented. Several genera, mostly characterized by strongly developed columellar structures, are recognized, but study of classification and comparison with the numerous forms described from other areas are still in progress. Promise of the stratigraphic usefulness of the corals is seen.

CORRELATION AND SIGNIFICANCE OF THE MICTAW FAUNA OF GASPÉ

BY STUART A. NORTHROP

Although the Mictaw series of Port Daniel, Gaspé, has already been described briefly by the writer and others, its fauna has not yet been made known. The series comprises several thousand feet of black shales and tuffaceous graywackes. Logan found graptolites here in 1843 but these were lost by shipwreck, and no further collecting was done until 1927.

The fauna totals 27 species, including 17 graptolites (examined by Ruedemann), 8 brachiopods, 1 conularid, and 1 cephalopod. This is a new assemblage of two forms—*Diplograptus amplexicaulis* and *Climacograptus spiniferus*—being definitely known elsewhere. Relationship is indicated with the Dolgeville and Snake Hill of New York and with the transition beds between Trenton and Utica at Lake Champlain. The fauna is younger than the Tetagouche (50 miles southwest) and the Marsoui (85 miles northwest), both of which are Normanskill. The Mictaw represents late Trenton-Utica time and the *Dicranograptus clingani* zone of Great Britain and Scandinavia.

The occurrence of several thousand feet of Mictaw sediments at Port Daniel between the Cambrian (?) Macquereau group and the Middle Silurian Chaleur series, and the absence of Mictaw strata a few miles away at Anse-à-la Vieille, where Chaleur rests directly on Macquereau, is a striking manifestation of Taconian orogeny and of great erosion in late Ordovician-early Silurian time. The presence of abundant volcanic material in the Mictaw graywackes is significant, for Alcock and Jones have found an extensive belt of volcanic rocks to the north; it now appears that some of this volcanism must be of pre-Mictaw age.

LOWER CRETACEOUS ROCKY MOUNTAIN NONMARINE MICROFOSSILS

BY RAYMOND E. PECK

Charophyte oögonia and ostracods are common in the limestones of the Kootenai formation in central Montana and in the Peterson and Draney formations of the Gannett group in eastern Idaho and western Wyoming. The charophyte genera *Atopochara* Peck, heretofore known only from the Trinity of Texas and Oklahoma, *Clavator* Reid and Groves, and *Perimneste* Harris, heretofore known only from the Purbeck of England, are distinctive and abundant. The Ostracoda consist mostly of representatives of the genera *Cypridea* Bosquet and *Metacypris* G. S. Brady. Two of the ostracod species occur also in the Trinity of Texas and Arkansas, and the entire ostracod fauna bears a close resemblance to Upper Purbeck-Wealden of England. (Geological Society project.)

FORAMINIFERA OF SUBMARINE CORES FROM NORTH ATLANTIC

BY FRED B. PHLEGER, JR.

The Foraminifera of several new submarine cores from the continental slope and shelf south of Georges Bank and near Nantucket Lightship have been studied. In most of the cores from the continental slope an Arctic fauna of late Pleistocene age has been identified, and this is to be correlated with similar faunas reported in other cores from the North Atlantic, the South Atlantic, and the Arabian Sea. The significance of faunal changes in very deep sea cores, where only pelagic Foraminifera are present, is examined. Faunas indicating cooler water found in such cores are considered correlatives of the true Arctic faunas found in some continental slope cores.

The bases for interpreting details of environment represented by stratigraphic faunal changes in the cores are discussed. Little pertinent information on the general ecology of the living Foraminifera is available, and some interpretations which are based upon stratigraphic faunal changes are not necessarily valid; there is no certain evidence at the present time for great changes in depth in the region penetrated by any of the cores collected by Stetson. Preliminary studies on depth ranges of living Foraminifera on the continental slope show that certain species are characteristic of the upper part of the slope, and others of the lower slope. The dividing zone between these is about 800 to 1000 meters, and the faunal separation may be due to temperature. Initial errors of collecting and sampling cores are studied and discussed. (Geological Society project.)

"BONE POCKET" IN LOWER PERMIAN LUEDERS FORMATION OF BAYLOR COUNTY, TEXAS

BY WILLIAM F. READ

During the summer of 1939 a field party from the University of Chicago discovered a new, apparently untouched "bone pocket" in the Lower Permian Lueders formation of Baylor County, Texas. The "pocket" is a lenticular mass of gray silt and silty clay, about 15 feet thick, interbedded between red clays, and extending for half a mile along both sides of a broad creek bottom.

Because of the distinctive character of the sediments, the abundance of vertebrate material (including footprints), and the presence also of plant remains, this deposit was selected as the object of an intensive search for evidences of the particular environmental conditions responsible for the character of the sediments and for the accumulation and burial of remains of certain types of plants and animals.

The entire area of outcrop was planetabled on a scale of 50 feet to the inch; the location of every identifiable scrap of bone and every plant was plotted; and representative sediment samples were collected. Laboratory study revealed that three amphibians, four reptiles, three fish, several invertebrates, and at least a dozen different kinds of plants were represented. Work on the sediments has not progressed beyond the stage of size-frequency distribution analyses.

Much remains to be done, but the experience gained so far has led at least to certain definite conclusions regarding field and laboratory techniques applicable to problems of this kind.

PLEISTOCENE MOLLUSKS FROM MARGARITA ISLAND, VENEZUELA

BY HORACE G. RICHARDS

A fauna of fossil mollusks from Juan Griego, on the north shore of Margarita Island, Venezuela, is recorded. Eighteen species are listed. one of which is new.

All the remaining species are known to be living in shallow warm seas today. Because of the high percentage of recent species, a Pleistocene age is suggested for the fauna.

DISCOVERY OF A MARINE FAUNA IN EASTEND FORMATION OF SASKATCHEWAN, CANADA

BY LORIS S. RUSSELL

The Eastend formation of Saskatchewan is homotaxial with the Lower Fox Hills beds of Montana and the Dakotas. It has not previously yielded more than a few traces of marine mollusks. During the summer of 1940 the writer, while engaged in stratigraphical studies under a grant from the Penrose Bequest, discovered a rich marine pelecypod fauna in the formation just south of the town of Eastend. The stratigraphical position is 88 feet below the top of the formation and at least 30 feet above typical Bearpaw shale. The specimens, although well preserved, are extremely fragile, and the matrix is very friable, so that special methods akin to those of vertebrate collecting had to be employed in obtaining specimens. Preliminary studies indicate that the fauna has elements in common with that of the middle Eastend beds in southeastern Alberta, but certain characteristic members of the latter fauna are absent, so that the Saskatchewan assemblage may be younger. Detailed study of this fauna should supply information on the withdrawal of the Cretaceous sea from the northern Great Plains. (Geological Society project.)

NEW GENUS OF GASTROPODA, PROBABLE ANCESTOR OF THE GRANGERELLIDAE FROM UPPER CRETACEOUS OF ALBERTA

BY LORIS S. RUSSELL

Prograngerella sperata, n. gen. and sp., is described from the Oldman formation (upper Belly River) of southeastern Alberta. It has a small, low shell, the aperture of which has the thickened lip and the palatal and basal teeth characteristic of the Grangerellidae, but the body whorl of which is normal and not deflected toward the apex. Grangerellidae have been previously known from the Paleocene of Alberta and the Lower Eocene of Wyoming. *Prograngerella* has the expected characteristics of the Cretaceous ancestor of the family.

UPPER CRETACEOUS PELECYPODS OF THE *VENERICARDIA BEAUMONTI* GROUP FROM IRAN

BY R. F. RUTSCH AND HUBERT G. SCHENCK

Frank Reeves and Walter P. Wilson in 1938 collected a number of pelecypods from southeastern Iran about 50 miles northwest of the Afghanistan-Baluchistan-Iran frontier, at locality R-115. A study of these specimens leads to the following conclusions: (1) Specimens of *beaumonti* and its close relatives should be allocated to the genus *Venericardia* Lamarck, 1801, typified by *Venericardia imbricata* Gmelin, 1791; (2) the specimens from eastern Iran belong to a new species which is assigned to a new subgenus characterized by spinose radial ribs; (3) the new species is of late Cretaceous age. The Iranian species is described in detail and comparisons are made with *beaumonti sensu stricto, ameliae, baluchistanensis,* and other related forms. The paper is thus a continuation of a previous publication by Rutsch in 1936.

TARSUS AND LOCOMOTOR METHODS OF EARLIER TETRAPODS

BY BOBB SCHAEFFER

A motion picture record of the locomotion of *Triturus* and *Ambystoma* makes it possible to analyze in detail the movements and positions of the limb segments during the propulsive and recovery phases of a complete locomotor cycle. This information throws light on the arrangement of the crural and pedal musculature and forms a basis for making deductions concerning the structure and function of the labyrinthodont and primitive reptilian tarsus. Motion pictures of the locomotion of the alligator offer a similar opportunity for studies on the tarsus of certain of the more advanced reptilian orders. Finally, conclusions can be made concerning the evolution of the foot from the primitive tetrapod condition to that found in the various orders of reptiles, particularly in those ancestral to the mammals.

PYRITE FAUNAS OF WASHITA AND EAGLE FORD GROUPS OF TEXAS CRETACEOUS AND THE PALEOECOLOGICAL SIGNIFICANCE

BY GAYLE SCOTT

The stratigraphic and geographic distribution of these faunas is reviewed, and the manner of preservation of the fossils is discussed. Attention is called to the fact that lithology and conditions of sedimentation of the formations in which the fossils occur abundantly are closely similar. Paleogeographic conditions are considered, and comparisons are made with Cretaceous pyrite faunas in other areas. It is noted that most species are small, and it is suggested that unfavorable living conditions resulted in dwarfing. Cephalopods are numerous but are predominantly of the uncoiled types. Possible explanations of this phenomenon are offered.

OSTRACODA FROM THE OTTER FORMATION, MISSISSIPPIAN, OF CENTRAL MONTANA

BY HAROLD W. SCOTT

The ostracode fauna from the Otter formation is characterized by middle and upper Chester types. *Parparchites, Sansabella, Jonesina, Glyptopleura,* and *Bairdia* are the most common genera. A new genus, *Lochriella,* is proposed for certain forms related to *Sansabella.*

Seven species are common to the Otter and Sacajawea, and five species to the Otter and Chester. The upper part of the Otter is correlated with the middle and upper Chester, probably extending as high as the Clore formation. *Sansabella reversa* Morey, described from the Sacajawea, is common in the upper Otter of Montana and is abundant as well as restricted to the Clore of Illinois and Kentucky.

The ostracods are not related to Salem forms. Only one species, a long-range type, is common to the two horizons.

NEW FOSSIL LOCALITIES IN TEXAS

BY E. H. SELLARDS

During the past 2 years collections of fossils have been made by The University of Texas and the Work Projects Administration from Permian, Triassic, Cretaceous, Miocene, Pliocene, and Pleistocene formations in Texas. Some of the more important results are the following: Artifacts have been found associated with Pleistocene fossils at several localities. A new vertebrate fauna has been obtained from the Pliocene Goliad formation in Bee and Live Oak counties. A collection of Miocene

vertebrates is being made in Polk County. The upper Cretaceous of Fannin and Grayson counties has afforded a large fauna including marine reptiles, fish, lobsters, and crabs, many of the smaller fossils being preserved in concretions. Quarries in the upper Triassic of Howard and Crosby counties have yielded a considerable series of reptiles and amphibians. In these collections the problematic reptile *Trilophosaurus* Case, heretofore known only from fragmentary remains, is represented by parts of many skeletons, one skeleton being nearly complete. Quarries for Permian fossils have been opened in Taylor and Clay counties.

INDEPENDENCE SHALE OF IOWA

BY MERRILL A. STAINBROOK

Newly discovered outcrops, artificial exposures in recently opened quarries, and suites of samples from new deep wells corroborate previous observations that the Independence shale lies immediately below the Cedar Valley limestone. The shale is widely distributed but is absent in the northern and southern portions of the Iowa Devonian area. It appears to lie unconformably on the Davenport lithographic limestone and beneath the Cedar Valley also as the latter overlaps the Independence, in places lies on Davenport, and has cut through to the Spring Grove. Lithologically and faunally the shale differs from the Wapsipinicon and is more closely related to the Cedar Valley.

The large fauna of the Independence is characterized by *Hypothyridina* cf. *emmonsi* (Hall and Whitfield). *Rhynchonella ambigua* Calvin, *Douvillinella variabilis* (Calvin), *Orthis infera* Calvin, *Macgeea parva* Webster, *Cyphaspis brandonensis* Walter, and species of *Ponticeras, Grünwaldtia, Romingeria, Ambothyris,* and *Arthracantha.* Similarity to the Lime Creek fauna has been noted by Calvin and others, but study shows varietal and specific differences between related forms. Significant absentees from the Independence are *Spirifer hungerfordi, Spirifer whitneyi, Floydia gigantea, Cranaena navicella,* and any representative of *Prismatophyllum, Strombodes, Chonophyllum, Cystiphyllum,* or *Phillipsastrea* (*Pachyphyllum*). Resemblances of the two faunas are explained by similarity of depositional facies and descent. The Independence is Upper Devonian as shown by the fauna and emphasizes the Upper Devonian position of the Cedar Valley.

SILURIAN STRATA OF AROOSTOOK COUNTY, MAINE

BY WILLIAM H. TWENHOFEL

The Silurian strata of Aroostook County, northern Maine, are situated in the region of Appalachian folding. The structure is complex, and the fewness of exposures renders solution difficult. Seven units were defined by Williams and Gregory which were arranged as follows:

Chapman sandstone; Square Lake limestone; Ashland limestone; Ashland shale; Sheridan sandstone; Graptolite shale; Aroostook limestone.

The Chapman sandstone and Square Lake limestone were subsequently shown to be Devonian, the former Oriskany and the latter Helderberg. Fossils listed from each of the other stratigraphic units either contained many errors of identification or there was mixing of fossils from different formations of which some could not be Silurian. For instance, the faunal list from the Ashland limestone contained 44 species of which 17 have never been found in Silurian strata.

Studies of collections made by the author in 1938 and collections borrowed from the New York State Museum have raised doubts as to the Silurian age of the Aroos-

took limestone. The suggestion is made that this unit, of which only a part is limestone, may be Ordovician. Field relations and fossils suggest that the Graptolite shale and Ashland shale are parts of one stratigraphic unit, that the strata designated Ashland limestone are lenses of limestone in this shale, and that the Sheridan sandstone succeeds the Ashland shale. As thus interpreted, the section in descending order becomes

Sheridan formation
Ashland formation
Aroostook formation

The Aroostook is possibly of Ordovician age.

The aspect of the fauna is early Silurian in the interval from late Clinton to early Niagaran. There are some faunal elements which suggest a slightly later age.

OZARKIAN AND CANADIAN CEPHALOPODS: PART I, NAUTILICONES

BY E. O. ULRICH, AUG. F. FOERSTE, A. K. MILLER, AND W. M. FURNISH*

Coiled nautiloids are not known to occur in the Ozarkian but are widespread in the Upper Canadian of North America. The best preserved and most diversified faunas are from the Lake Champlain region. Also, numerous specimens have been collected at several localities in western Newfoundland and the Mingan Island area. The Southern Appalachian and the Ozark regions have yielded a sequence of faunas which are locally well represented. These few areas constitute all the important occurrences, and only a very small number of questionable specimens are known outside of North America.

All the Canadian nautilicones are rather unspecialized forms with orthochoanitic siphuncles. They vary chiefly in the shape of the conch and the position of the siphuncle. Primarily on the basis of these features, they have been placed in four families: the Deltoceratidae, Plectoceratidae, Tarphyceratidae, and Trocholitidae. Altogether about 75 species are now known and these are being referred to 17 genera. (Geological Society project.)

PENNSYLVANIAN SCAPHOPODA AND CEPHALOPODA FROM NEW MEXICO

BY JOHN A. YOUNG, JR.

A description is given of the scaphopod and cephalopod fauna of the Pennsylvanian Magdalena group of the northern Sangre de Cristo Mountains of New Mexico. Two new species of *Dentalium*, three new species of *Huanghoceras*, and one new species each of *Pseudometacoceras*, *Mooreoceras*, and *Anthracoceras* are described.

*Introduced by A. K. Miller.

PACIFIC COAST BRANCH MEETING AT LOS ANGELES IN APRIL

PLEISTOCENE HISTORY OF THE NEWPORT BAY AREA, SOUTHERN CALIFORNIA

BY STEPHEN C. BRUFF*

The only Pleistocene beds exposed in this area are equivalent in age and lithology to those of the Palos Verdes sands of the San Pedro area. They are largely undeformed and lie unconformably as a capping bed over the folded Tertiary rocks that make up the Costa Mesa.

The water temperature of Palos Verdes time in this area, as indicated by a fauna of 169 species of marine mollusks, was approximately 3.4°F. warmer than the present littoral temperatures. A fauna of similar species might be found living today along the coast off Cape Colnett, Lower California.

Two types of beaches occurred in this area: protected shores, primarily rocky, along the sea cliff that existed at the base of the San Joaquin Hills; and the bays and estuaries that appeared from time to time in conjunction with the Santa Ana River mouth on the broad terrace that today is known as the Costa Mesa.

The canyon of the Inner Newport Bay was cut through the northwest end of the San Joaquin Hills by the Santa Ana River at a time of emergence prior to the submergence of Palos Verdes time. The Palos Verdes sands filled the inner bay but were later almost entirely removed by the river in the most recent emergence.

EVOLUTION OF THE GENUS *ASTRODAPSIS* ON THE WEST COAST

BY BRUCE L. CLARK

The echinoid genus *Astrodapsis* first appears on the West Coast in the lower part of the Upper Miocene. The highest zone which has been recorded is in the upper zone of the Lower Pliocene. In this paper the evolutionary series of species from the Briones formation in the basal Upper Miocene to the Upper Jacalitos will be considered. A number of distinct zones are outlined, and two groups of *Astrodapsis* are recognized. One may be referred to as the *Astrodapsis tumidus* group and the other as the *Astrodapsis whitneyi* group. These two groups parallel each other from the Upper Miocene to the Pliocene. The probable relationships of the various new species are discussed, and some of the present nomenclature is revised.

PLIOCENE AND PLEISTOCENE FOSSILS AT RINCON CREEK, SANTA BARBARA COUNTY, CALIFORNIA

BY JACK C. COOPER AND RAYMAN STURDEVANT†

A fossil locality half a mile from the mouth of Rincon Creek, Santa Barbara County, California, has yielded a prolific megafauna. The fossils are found in unconsolidated silts, sandy silts, and sands about 550 feet thick, separated unconformably from Miocene Rincon shales below and terrace gravels above. Eleven faunules of megafossils have been recognized. Faunules two and three contain *Pecten bellus* and are correlated with the Pliocene. Faunules four and five are regarded as Pliocene, and all the upper zones are correlated with the Pleistocene because of temperature variations as demonstrated by fossils.

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*Introduced by Bruce L. Clark.
†Introduced by U. S. Grant.

FORAMINIFERAL FAUNULE FROM THE AVENAL SANDSTONE (MIDDLE EOCENE) OF REEF RIDGE, CALIFORNIA

BY ROBERT W. CRUME*

Significant foraminiferal faunules were collected in the Avenal sandstone of Reef Ridge, Kings County, California, 2300 feet north and 1350 feet east of the southeast corner of section 27, R. 17E., T. 23S. Three fossiliferous samples were collected at an interval between 300 to 400 feet above the base of the Avenal, 50 to 150 feet below the base of sandstone "reef" mapped as the top of the Avenal, and 1300 to 1200 feet below the base of the Temblor formation. Conformably overlying the Avenal and unconformably underlying the Temblor is 1000 feet of siltstones and shales that have been mapped as the Kreyenhagen formation.

These allocated faunules contain, among other species: *Asterigerina crassaformis, Bulimina corrugata, B. curtissima, Cibicides aff. cushmani, C. aff. martinezensis, Dentalina jacksonensis, Eponides minima, E. umbonata, Gyroidina soldanii octocamerata, Nonion aff. umbilicatulus, Plectofrondicularia aff. packardi, Pullenia eocenica, Pulvinulinella tenuicarinata, Robulus aff. articulatus var. texana, Spiroplectoides directa, Uvigerina aff. churchi, U. garzaensis, U. aff. jacksonensis,* and *Vaginulina* sp.

The significance attached to these faunules is that they recur without marked change in composition in the stratigraphically higher beds mapped as Kreyenhagen. Thus, it is sometimes difficult to distinguish faunules of the Kreyenhagen formation from the faunules allocated here to the Avenal sandstone.

FOSSIL FISH FROM THE MIOCENE OF THE PALOS VERDES HILLS, CALIFORNIA

BY LORE DAVID †

Fossil fish have been found in a limited area on the shore line of the Palos Verdes Hills half a mile west of White Point near San Pedro, California. The formation is late middle or early upper Miocene. The variety of fish forms is small. Two genera are well established: a giant butterfly ray (*Pteroplatea* Muller and Henle) and a thread-herring (*Opisthonema* Gill). Both fish are shallow-water types of the warmer seas. Numerous remains of Bonitos (*Sarda* Cuv.), all fragmentary and imperfect, are of importance. A subtropical shallow sea is indicated as the place of deposition of this particular assemblage. This is the first fossil found of the cosmopolitan genus *Pteroplatea*. These or closely similar genera are still extant. (Geological Society project.)

UPPER MIOCENE FISH FROM NORTHERN RIM OF THE SANTA MONICA MOUNTAINS, CALIFORNIA

BY LORE DAVID †

The soft white diatomaceous shale of the upper part of the Modelo formation yielded an abundance of fossil fish at a locality near Van Nuys. About 250 specimens have been collected in a small portion of the formation. Strata containing fish are interfingered with barren layers of volcanic ash and layers of sandstone and mudstone. The variety of fish forms is small. Nine genera are represented, 5 of these being bathypelagic. The bathypelagic types form 75 per cent of the entire collection; lantern fish alone represent 65 per cent; the remaining genera, mostly

* Introduced by Hubert G. Schenck.
† Introduced by Chester Stock.

represented by fragmentary remains, are pelagic forms of the littoral zone. The only explanation for the particular composition found at this site is on the basis of ecologic conditions. The fish material must have been deposited at the bottom of a steeply inclined coastal shelf. (Geologic Society project.)

EOCENE AND OLIGOCENE CORAL FAUNAS OF WASHINGTON

BY J. WYATT DURHAM

Numerous corals have been found in the Eocene and Oligocene strata. Analysis of the faunas reveals that there are about 35 species representing 24 genera. Of these genera, 15 are distinctly tropical in their modern occurrence; the remainder are either extinct or widespread in the recent faunas. The corals of the middle Eocene Crescent formation have a definite tropical aspect, the upper Eocene and lower Oligocene somewhat less distinctly so. The corals of the lower conglomerates of the upper Oligocene Blakeley formation have a decided warm temperate aspect.

STRATIGRAPHIC OCCURRENCE OF PECTEN SANCTAECRUZENSIS IN CALIFORNIA

BY KENNETH L. EDWARDS *

Pecten (Pecten) sanctaecruzensis Arnold was described from Twobar Creek, Santa Cruz County, California, where it was obtained from "beds which appear to be transitional from the Oligocene to the lower Miocene," although Arnold lists it from the San Lorenzo formation, as did Branner, Newson, and Arnold. That the species occurs in the Vaqueros formation, as mapped in the Santa Cruz folio, was pointed out by Schenck. The only published record of the species outside the Santa Cruz area is that by Loel and Corey who stated that in Monterey County the "type Vaqueros" formation rests upon a thick series of coarse, massive sandstones and conglomerates of Oligocene or Eocene age with a *"Pecten sanctaecruzana"* fauna at the top. It is in this area that the writer has made his detailed field studies, including the measuring by plane table of a section at The Indians, Junipero Serra quadrangle. *Pecten sanctaecruzensis*, which here occurs 850± feet and 1050± feet stratigraphically below the superjacent Monterey shale, is associated with *Chlamys perrini, Dosinia margaritana,* and other species which are present in the Vaqueros formation at its type locality 10 miles to the northeast. The species is thought to be restricted to the Zemorrian stage.

UPPER MIOCENE EQUIDAE FROM THE SAN ANTONIO MOUNTAINS NEAR TONOPAH, NEVADA

BY PAUL C. HENSHAW †

Located on the same 3-foot horizon, two quarries laterally less than 300 feet apart furnished a collection of moderately well preserved equid material in all growth stages. Over 100 merychippine and more than 10 hypohippine individuals are represented. The material demonstrates a narrow range of variation for individuals of approximately the same growth stage. Furthermore, the collection affords an opportunity to make detailed osteological comparisons between the genera *Merychippus* and *Hypohippus*. The forms, which have been referred to *Merychippus calamarius* Cope and to *Hypohippus* near *nevadensis* Merriam, represent an Upper Miocene stage.

* Introduced by Hubert G. Schenck.
† Introduced by Chester Stock.

ORDOVICIAN TRILOBITES OF NEVADA

BY SAMUEL HOLLIDAY *

Specimens of *Pliomerops barrandei* (Billings), representing more complete material than hitherto published, are described from Hamilton, Nevada, the type locality of the Pogonip limestone, and from Manhattan, Nevada, the type locality of Bassler's "New Ordovician Sponge Fauna". The new material bears out the statement of Phieger (1933) that *P. nevadensis* is a synonym of *P. barrandei* (Billings). Material from near Beatty, Nevada, contains a new species related to *P. barrandei* and a new species of *Pliomerops* having affinities with *Cybelopsis*.

The fauna from the type locality of the Pogonip limestone indicates a Middle or Upper Ordovician age. The new species from Beatty are Lower Ordovician.

EOCENE STELLATE ORBITOIDAL FORAMINIFERA FROM THE TYPE TEJON FORMATION, GRAPEVINE CANYON, CALIFORNIA

BY JAY G. MARKS **

In January 1939 Robert T. White discovered large Foraminifera in the basal conglomerate of the Tejon formation on the nose of a hill on the west side of Grapevine Canyon, 900 feet west of the dot over the "i" in "Grapevine" (on the Tejon topographic map), and 900 feet S. 73°W. from the cattle guard where the General Petroleum pump station road joins U. S. Highway 99. Here the Tejon strata are unconformable upon a granitic terrane. The fossils are 190 feet stratigraphically below beds which contain *Ficopsis hornii, Galeodea tri-tuberculata* n. var., *Pseudoperissolax blakei, Turritella uvasana,* and *Venericardia hornii.*

The stellate orbitoid is a small species of *Actinocyclina*. The following description is based upon 85 incomplete specimens: diameter of largest specimen, 4.8 mm.; thickness, 1.1 mm.; shape discoidal with mamelon extending halfway to periphery; seven rays modifying the periphery only slightly; 18 tiers of lateral chambers; equatorial chambers rectangular; embryonic chambers reniform, embracing.

This species is closely related to *Actinocyclina aster* Woodring (1930) but differs chiefly in the smaller size and lesser number of rays. It compares closely with specimens from the Crescent formation, Washington, described and figured as *A. aster* variety B by Berthiaume. It is associated with a small, robust *Discocyclina, Nodosaria, Quinqueloculina, Robulus,* a large species of *Ostrea, Spiroglyphus* (?) *capayensis,* and abundant calcareous algae.

PALAEOCYCLUS PORPITA, SILURIAN CORAL, FROM THE PANAMINT RANGE, CALIFORNIA

BY JAMES F. MC ALLISTER †

Occurrence of *Palaeocyclus porpita* (Linné) in western United States is recorded for the first time. The coral was found near Tin Mountain in the northern part of the Panamint Range. The identity of the California and Gotland species was established by comparison with Gotland specimens at Stanford University. On the basis of the new material from the Panamint Range, *P. rotuloides* (Hall) from New York and *P. michiganensis* Bassler from Michigan, the only eastern American species described, appear to be gradational variants of *P. porpita.*

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* Introduced by Siemon W. Muller.
** Introduced by Hubert G. Schenck.
† Introduced by Siemon W. Muller.

In Europe *P. porpita* occurs only in uppermost Lower Silurian and lower Middle Silurian. In eastern North America the genus appears to be restricted to Clinton of the lower Niagaran, lower Middle Silurian. The California specimens of *P. porpita* corroborate the Silurian age of the associated *Halysites* fauna which is known from other localities mapped in the northern part of the Panamint Range.

BLACK HAWK RANCH QUARRY FAUNA: THE VALUE OF LARGE COLLECTIONS IN MAMMALIAN PALEONTOLOGY

BY K. A. RICHEY

During the summers of 1937–1939 quarrying operations have been carried on in a very rich bone bed in the Lower Pliocene deposits of the south side of Mt. Diablo, 30 miles from Berkeley, California. The representation of genera is very complete, 19 genera of mammals having been so far recognized, as well as bird and reptile remains. The association of the materials is strictly contemporaneous. A poorly preserved, but fairly abundant flora is found in the same bed, a situation very rare in mammalian fossil occurrences. The study of the horses, just completed, shows the occurrence to be late lower Pliocene, equivalent to the uppermost Ricardo and the upper Chanac. It is probably somewhat younger than the Siesta and Columbia (Springfield Shaft) occurrences.

Faunas of this sort have an importance even greater than the mere quantity of material would indicate. They constitute reference points or standard datum horizons to which nearly all related faunas, even fragmentary ones, can be compared. They make possible the study of individual variation in the more abundant species, as is demonstrated in the Black Hawk Ranch Quarry fauna by a nearly complete series of wear stages in teeth of *Hipparion*. The association of the milk teeth may demonstrate a case of recapitulation and thus have a bearing on phylogeny. Opportunity is provided for the application of statistical methods of description and analysis. A better cross section of the entire fauna of a single time and province is obtained, especially of the smaller forms.

LATER TERTIARY SUCCESSION OF LIFE ZONES ON THE SOUTHWEST SLOPE OF MOUNT DIABLO

BY K. A. RICHEY

In the entire Upper Miocene and Lower Pliocene section of the southwest side of Mt. Diablo, well-defined formation boundaries are lacking. Except for the intercalation of two tuff members which may be used as key horizons, lithologic changes are gradational. The upper 1000 feet of what were previously thought to be marine strata of questionable Jacalitos age has been found to contain remains of land mammals and is of continental origin. The terms "Cierbo", "Neroly", "Jacalitos", "Green Valley", and "Black Hawk Ranch Quarry" have greater validity as faunal and floral zones than as lithologic units. The strata in this section are overturned along the crests of ridges transverse to the strike but not overturned in the bottoms of the canyons. The overturning is due to the excavation of strike valleys in the thicker shale members and the slumping of the more resistant members into these valleys.

The sequence of faunas and floras in this section is exceptionally clear. From youngest to oldest, the succession of fossil zones is as follows: (1) Black Hawk Ranch Quarry mammalian fauna associated with "Green Valley Florule"; (2) a zone con-

taining small horses of the *Nannippus tehonensis* type; (3) a marine horizon with a fauna of questionable Jacalitos age; (4) a thin zone of leaf-bearing shales containing an abundant flora as yet undescribed, but apparently distinct from the San Pablo flora (Carleton Condit, oral communication); (5) Neroly invertebrate zones; (6) Cierbo invertebrate zones; (7) Briones horizon; (8) "Monterey".

NEW EVIDENCE ON THE FAUNAL RELATIONS OF THE RICARDO, MINT CANYON, AND BARSTOW FORMATIONS

BY K. A. RICHEY

In comparing the fossil horses of Black Hawk Ranch with those of the Ricardo beds, a stratigraphic distribution of forms was observed in the Ricardo which it is believed will finally settle the much debated question of the faunal relations of the Mint Canyon formation. It was found that a number of faunal zones could be recognized within the 3000+ feet of strata of the Ricardo formation, based upon distinctive types of horses, mostly hipparions. The distinctive species of *Hipparion* and *Pliohippus* characteristic of the Black Hawk Ranch Quarry fauna occur together in the uppermost fossiliferous zone of the Ricardo; the peculiar species found in the Mint Canyon formation, some of which are notable for their large size, are identical with or closely allied to forms in the lower part of the Ricardo, particularly a zone immediately above and below the uppermost lava flow. Primitive characters were observed in the teeth of the lower Ricardo and Mint Canyon horses which are in keeping with their earlier age, although the large size and considerable degree of hypsodonty which some of them show is a bit surprising in view of the probability that these are the earliest *Hipparion* faunas known on the Pacific Coast. The lower Ricardo and Mint Canyon horses are only slightly more progressive than those of the Barstow and are probably not far removed in age. They are quite distinct specifically from, and more primitive than, the horses of Black Hawk Ranch Quarry and the uppermost Ricardo.

STRATIGRAPHIC STUDY OF THE *AUCELLA*-BEARING BEDS OF THE CALIFORNIA COAST RANGES

BY ROBERT L. RIST *

The *Aucella*-bearing beds of the California Coast Ranges have been referred to various time stratigraphic units by students of Pacific Coast Mesozoic history. Recent studies of the genus *Aucella* give evidence of the Jurassic age of certain of these beds in the northern and southern Coast Ranges.

It is improbable that *Aucella* of western North America will ever be used for fine stratigraphic differentiation. However, the specifically identical nature of certain American and European forms, as well as the similarity of faunal sequence, strongly suggests that the beds bearing these forms in Europe and western North America should be referred to like time intervals.

Aucella characteristically occurs in great abundance. This creates for the worker special problems. The richness of the fauna and a tendency of the genus to be pleomorphic tend to obliterate, or at least render indistinct, the species. This has caused *Aucella* to have been broken up into many species, a number of which probably are not legitimate.

* Introduced by Bruce L. Clark.

MIOCENE SESSILE BARNACLES FROM SOUTHERN CALIFORNIA

BY W. THOMAS ROTHWELL, JR.

New information is presented on the systematic position and stratigraphic relations of a form of *Balanus concavus* from the Vaqueros formation of Ventura County. The author is conducting an ecologic study of recent barnacles and in the light of this study he suggests possible conditions for closely related fossil forms. Slides of hitherto unknown opercular valves are shown, and the value of the Cirripedia in stratigraphic paleontology is discussed.

ABSTRACTS OF SECTION E, AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

DECEMBER MEETING AT PHILADELPHIA

HYBRIDIZATION AND SHEARING IN BANDED GNEISSES NEAR PHILADELPHIA

BY ELIZABETH ARMSTRONG

The area under discussion extends for approximately 30 miles along the strike of the pre-Cambrian gneiss of the Piedmont Plateau from Trenton, New Jersey, to the Delaware County line near Bryn Mawr, Pennsylvania.

Injection of felsic material into a plagioclase amphibolite has produced a banded hybrid gneiss which has been subsequently sheared as evidenced by vertical, winding mylonite zones west of Wissahickon Creek and by schistose zones to the east. The character of the injection varies from magmatic intrusion of bodies showing well-defined contacts to hydrothermal penetration. The following reactions are observable in the mixed types: biotite replacing hornblende; plagioclase becoming more sodic with formation of epidote in enclosed laths; potash feldspar replacing plagioclase; quartz, potash feldspar, and plagioclase replacing hornblende and biotite.

Cataclastic deformation of the mixed rock has resulted in the trituration of all the minerals except, in most cases, the feldspars. Large porphyroblasts have grown in some of the mylonites, and recrystallization of the groundmass has resulted in barely discernible schistosity. Thorough recrystallization characterizes the schistose shear zones in the eastern part of the region.

GRANITIZATION IN WESTERN NEW ENGLAND

BY GEORGE W. BAIN

Three main aspects of granitization are: features of waning intensity in the marginal zone, conditions during the process, and time of occurrence. Some effects are visible as far west as the Taconic Mountains from Brandon, Vermont, southward to the Highlands of the Hudson in New York.

Epigenetic garnet, tourmaline, epidote, actinolite, chlorite, adularia, albite, and metallic sulphides in disseminated grains and large masses in the Cambro-Ordovician quartzites and limestones represent outposts of granitization. Degraphitized rock masses mark others. Solution-permeated rocks have flexural folds (girdle fabrics), whereas shear folds (shear fabrics) predominate outside the granitized zone.

The epigenetic minerals are principally high-temperature, high-pressure types. Appearance of flexural folding where the solutions passed suggests paratectonic granitization. Absence of veins from folded beds indicates closing of fissures by high pressure.

All granitization antedates intrusion of the subalkaline lamprophyre dikes (Monteregian series). Abundant vesicles indicate low magma pressure and a shallow cover of cool rock. The dikes intrude both Cuttingsville syenite, which is the youngest intrusive to crystallize under high pressure, and also the metamorphosed Ordovician dunite and saxonite intrusives of the ultrabasic belt. The Bernardston, Massachusetts, area of lower Devonian limestone is changed to lime silicates. This area and the high pressure existing during intrusion of the alkaline rocks at Cuttingsville place the age of the main granitization as contemporaneous with the Shickshock rather than the earlier Taconic disturbance.

PALEOZOIC IGNEOUS ACTIVITY IN NEW ENGLAND

BY MARLAND P. BILLINGS

Extrusive Paleozoic rocks in New England are flows and pyroclastics with the composition of basalt, andesite, dacite, quartz latite, trachyte, and rhyolite. Many, and perhaps all, of the Paleozoic systems are represented. Volcanics that may be Cambrian are found along the coast of Maine. Volcanics, almost certainly Ordovician, are common in western New Hampshire. Silurian volcanics are developed along the coast of Maine, and there are Devonian volcanics in western New Hampshire, northern Maine, and northeastern Massachusetts. Volcanics which are probably Mississippian occur in New Hampshire and eastern Massachusetts. Pennsylvanian volcanics are known in southern Massachusetts. Volcanics that are probably Permian are found in Rhode Island and eastern Massachusetts.

Probable late Ordovician granitoid rocks crop out in western New Hampshire and western Connecticut. Probable Devonian granites are known in western New Hampshire, central Massachusetts, central Connecticut, and along the Maine coast. The alkaline rocks of New England are probably Mississippian, and Permian granites are found in western Rhode Island and central Massachusetts. Many bodies are concordant and occupy great domes, lenses, or stocks. Others are discordant bodies, such as ring-dikes, stocks, and batholiths, and some have formed by the replacement of older sediments.

Some commonly accepted generalizations about the relationship between geosynclinal sedimentation, orogeny, and igneous activity are not verified by the data from New England, where magmas ranging in composition from basalt to rhyolite were erupted throughout the Paleozoic. Many of the New England intrusives arrived before or during orogeny and are concordant. The abundance of concordant Paleozoic intrusions in New England is at variance with the statement that large concordant intrusions are confined to the pre-Cambrian.

INTERPRETATION OF A CROSS SECTION OF THE BLUE RIDGE NORTH OF BALCONY FALLS, VIRGINIA*

BY ROBERT O. BLOOMER

A cross section drawn approximately normal to the strike of the rocks in the Blue Ridge anticlinorium just north of Balcony Falls illustrates an abrupt change in structure on either side of the main axis. The greater structural complexity east of the main divide, which roughly corresponds to this axis, is expressed by numerous faults with their associated phenomena, as well as by intensified folding in the fault blocks. In addition to the structure as shown in the cross section, localization of forces is also indicated by a considerable change in lithology. Rocks of the Chilhowee series are more metamorphosed east of the core of the Blue Ridge anticlinorium. Though not apparent from this cross section, the absence of known Catoctin volcanic series is significant. It is thought that the core of the anticlinorium may have assumed a massiflike character during a large part of the history of the area and thus induced some of the complexities of Blue Ridge geology.

MAPPING THE CHANGING WORLD: SUGGESTED IMPROVEMENTS IN MAPS

BY S. WHITTEMORE BOGGS

Maps should be devised to portray effectively the very significant improvements in travel, transportation, and communication facilities which have changed the world

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much more than we yet discern. Present map techniques seem inadequate in representing essential factors.

For travel speeds a type of map is suggested which is analogous to physical maps with layer tints or shadings between contours, in which the higher elevations are depicted in darker shadings. A map of this sort will enclose within a single curve the territory in which travel in a given range of speed prevails; the lighter the shading the less the obstacles and the greater the speed. A map of 1940, by comparison with one of 1800, represents a change as fundamental as if giant steam shovels and grading machines had leveled the mountains and made the surface of the United States almost as smooth as a billiard table. World maps of different dates would show that travel was slower in seventeenth century Europe than in the Roman Empire, where in recent decades it has exceeded the wildest dreams of earlier generations.

Maps may also be made to show the increasing distances at which commodities produced in different continents compete in a single market. This is one of the principal results of decreasing costs of transportation. Maps may likewise indicate, at least in a general way, the height of economic barriers which have been erected at international boundaries.

Such maps help to reveal that recent inventions and techniques, instead of making a "shrinking world," have lengthened the outreach of every people, multiplied impacts, and tended to intensify rivalries in distant markets. They also suggest that the solution of our problems may not be found in continental terms, but only in a world economy.

GEOGRAPHY AND THE DEFENSE OF THE CARIBBEAN AND THE PANAMA CANAL

BY G. S. BRYAN

The wealth of the West Indies has always aroused the cupidity of other countries. Conquest of these islands as colonies or the destruction of the Panama Canal would be the probable motives for an attack of this area.

Such attacks would come by sea and air, and a large expeditionary force would be needed. Probably the seizure of a base on the mainland would precede the direct attack.

The defense of this region would follow the usual formula of locating the invading forces, concentrating our own forces between them and their objective, and destroying them.

To accomplish this, bases should be established covering possible lines of attack. From these bases shore-based aircraft and surface ships could locate the hostile forces, and bombing planes, destroyers, and submarines could launch attacks against them.

Meanwhile, the heavy units of the fleet should be located back of this line in spacious deep-water harbors, from which they could readily be concentrated.

Recent international agreements covering the defense of the Western Hemisphere have made the necessary additional bases available for use in this plan. In the Atlantic, Bermuda, the Bahamas, San Juan, St. Thomas, Antigua, Sta. Lucia, and Trinidad form a chain of harbors well located and adapted for use by our light forces and aircraft.

Back of these are the deep-water harbors of Jamaica, Guantanamo, Gonaives, Port au Prince, Samana Bay, Trinidad, the Gulf of Cariaco, and Pozuelos Bay. These harbors provide excellent anchorages for the main body.

GEOLOGY AND HYDROLOGY OF SAINT CROIX, VIRGIN ISLANDS*

BY D. J. CEDERSTROM

The results of 4½ months of field work and data obtained by test drilling in Saint Croix, Virgin Islands, are summarized. The island consists of an older group of Cretaceous volcanic and sedimentary rocks, strongly folded and intruded by dioritic magmas during the Antillean revolution, and overlying Oligocene and Miocene soft clays and marls. The Tertiary rocks have been gently folded along west-southwest-trending axes and plunge to the west-southwest. The streams were subsequent upon this structure but later shifted to flow southward. Oscillations in sea level produced alluvium-filled valleys, alluvial terraces, and raised beaches and coral reefs.

Ground water can be obtained in moderate quantities from the old rocks, the Tertiary marls, and the alluvium. The alluvium is the most promising source for additional water supplies. The cause of well failures and the source of mineralization are discussed.

GEOLOGY AND HYDROLOGY OF THE SOUTHEASTERN VIRGINIA COASTAL PLAIN*

BY D. J. CEDERSTROM

The information at hand regarding the Coastal Plain of southern Virginia has been obtained from outcrops of strata, well logs, and geophysical investigations. Although these three sources offer incomplete information, data are at hand which bear on the following geologic problems: configuration and origin of the bedrock surface; structure in the Cretaceous and Tertiary sediments; the origin of these structures and their relation to the granitic bedrock.

The problems of hydrology to be considered are as follows: the chemical character of artesian waters with particular reference to softening by base exchange and the presence of high bicarbonates and fluorides; the relationship of fresh water to salt water and possibilities of salt-water contamination at Norfolk; and discussion of the piezometric surface, loss of water from storage, and perennial yield of water-bearing formations.

INDICATIONS OF CRETACEOUS NEW JERSEY SHORE LINES

BY ROBERT G. CHAFFEE

The scarcity of outcrops of the Cretaceous beds of New Jersey has led the author to the use of well records in an attempt to approximate the paleogeography of this region. The hypothetical sea-level outcrops were mapped, as indicated by the dip of several distinct formational bases in wells. The sea-level strike thus obtained, while necessarily not exact in detail, gives the major changes in strike and indicates the trend of the Cretaceous shore line.

ORIGIN OF THE LAUREL MIGMATITE

BY RANDOLPH W. CHAPMAN

The Laurel migmatite lies in the vicinity of Laurel, Maryland, about 17 miles southwest of Baltimore. A cover of Cretaceous gravels (Patuxent formation)

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obscures the areal extent of the migmatite, but it is at least 7 square miles. On the north the migmatite is bounded by Guilford granite, on the east by gabbro, on the west by Wissahickon schist, and on the south by Cretaceous sediments.

The migmatite is gray, medium- to fine-grained, and sugary. Chief minerals are quartz, oligoclase, biotite, and muscovite. In places it shows a poor alignment of mica flakes which gives it a faint foliation. Inclusions of schist which have been melted and drawn out give some parts of the migmatite a banded character.

The migmatite is believed to have been derived from the Wissahickon schist by simple melting or palingenesis. This is suggested by: (1) the close similarity in mineral composition between the migmatite and the Wissahickon schist, (2) the abundance of Wissahickon schist inclusions in the migmatite showing all stages of melting, and (3) the complete gradation from schist into migmatite along some contacts.

Melting of the Wissahickon schist is thought to have resulted from rising hot solutions. Intrusive contacts between the migmatite and the schist in a number of places suggest that the migmatite acted like a magma at least locally.

FORAMINIFERA OF THE MIOCENE OF MARYLAND

BY ANN DORSEY CLAPP

A study of the large fauna of Foraminifera from the Miocene of Maryland shows that they can be used to zone the three formations—Calvert, Choptank, and St. Marys—and that they lived under different ecologic conditions from those of contemporaneous Florida forms.

GEOGRAPHIC ASPECTS OF THE BURMA-YUNNAN ROAD

BY HELMUT DE TERRA

In 1938 the author witnessed the opening of the Burma-Yunnan road and made certain observations concerning its geomorphologic and human aspects. There is a close association between specific types of landforms and road engineering. Particularly, remnants of an old flat relief provide lines of communications on both sides of the meridianal stream province of Western Yunnan. This old relief is invariably connected with an older drainage pattern, the main characteristic of which is its adjustment to a northeast-southwest-trending system of faults. Valleys following this trend not only admit the Southwest monsoon but guide people's migrations. The geologic age of the flat relief units is tentatively dated as Miocene to early Pliocene.

The human aspects concern the ancient Chinese silk road leading from the Middle Yangtze via Talifu to Bhamo. Viewed against such a historic background the new highway appears to be a continuation of an old tradition of overland connections peculiarly augmented by the war emergency. Its intimate connection with the established and developing economies, on the one hand, and with the landforms, on the other, give this road a permanent character. For this reason it should be regarded as a major achievement in the defense of the Chinese Republic.

HEAVY MINERALS AND THE HISTORY OF THE COASTAL PLAIN

BY LINCOLN DRYDEN AND CLARISSA DRYDEN

Study of 1000 heavy mineral separations from rocks of Pennsylvania and adjoining States shows that: (1) The Coastal Plain sediments were derived essentially

from crystalline rocks, not from the Paleozoic or Triassic. Therefore, the writers believe that the Piedmont and the New Jersey Highlands were never covered by Cretaceous or Tertiary sediments. (2) The only significant break in composition of heavy mineral suites of the Coastal Plain sediments occurs at the Lower Cretaceous-Upper Cretaceous contact. (Geological Society project.)

SUBORDINATE STRUCTURES OF MASSANUTTEN MOUNTAIN SYNCLINE IN NORTHERN VIRGINIA

BY RAYMOND S. EDMUNDSON

Massanutten Mountain syncline, as defined by the outcrop of the Martinsburg shale, is a median fold of the Shenandoah Valley in northern Virginia. This formation lacks key beds for precise structural determinations, but the prevailing steep southeast dips and the wide outcrop necessitate the repetition of beds by several subordinate folds or by faults.

The area, 2 miles wide and 4 miles long, is located in Frederick and Clarke counties, Virginia, on the southeast limb of the syncline about 4 miles south of the West Virginia boundary. Ordovician rocks include Mosheim, Lenoir, Athens, and Chambersburg limestones. This belt is limited on the west by the Martinsburg shale of the Massanutten Mountain syncline and on the east by a wide expanse of Beekmantown Limestone. The Ordovician limestones are compressed into a series of closely spaced, parallel overturned folds with prevailing steep southeast dips. Some axial lines of the subordinate structures are inclined at an angle of 35 degrees. Fracture cleavage dipping at a high angle to the southeast is well displayed. The distribution of the formations is also affected by diagonal normal and reverse faults.

The subordinate small flexures developed in the relatively weak Martinsburg shale of the Massanutten Mountain syncline are believed to have been a controlling factor in the deformation of the immediately adjacent brittle and massively bedded limestones which crop out along the limbs of the major structure.

POCHUCK, BYRAM, AND LOSEE GNEISSES IN PENNSYLVANIA

BY DONALD M. FRASER

The Pochuck and Byram gneisses, extending from New Jersey southwestward into Pennsylvania, are defined in the light of present knowledge.

Gneissic material, having a composition between that of the Byram and of the Pochuck, has been called the Losee gneiss in New Jersey. This type of material in Pennsylvania is thought to be Byram with varying amounts of assimilated Pochuck and is not regarded as a different intrusive mass.

MAJOR FAULTING IN THE TRIASSIC OF NEW JERSEY

BY ALFRED C. HAWKINS

In the Triassic, just southwest of the shallow syncline occupied by the Watchung basalt flows, an interesting series of dislocations affect the sedimentary rocks and the associated diabase sill.

The main dislocation, the Hopewell block fault, was mapped in the Trenton folio, with a downthrow of 6000 feet or more on the southeast. Northeast of the town its strike changes from northeast to north, passing around the tip of Sourland Mountain.

All available dips and strikes in an area 20 miles square have been taken, and by comparison of the assembled data the structural conditions there have been determined. It appears that the throw of the fault increases to about 10,000 feet near the mountain's tip. There the fault turns abruptly toward the northeast again, and its throw rapidly decreases to zero northwest of Somerville.

Directly north of the mountain's tip there appears to be no actual faulting, but the dips and strikes in the shale are generally diametrically opposed along the sides of a well-defined zone extending northward from Sourland Mountain to the vicinity of Gladstone; there the zone merges into a known fault in the Triassic border. This zone is the locus of exceedingly sharp flexure, although no actual fault break has been found. The dip of the shales in the Gladstone area ranges up to 70 and 80 degrees, indicating profound subsidence on the western side.

Two miles north of Sourland Mountain there is a hinge point without dislocation.

ORIGIN AND GEOCHEMISTRY OF CONNATE WATERS IN WEST VIRGINIA*

BY E. T. HECK, CHARLES E. HARE, AND HOMER A. HOSKINS

The waters considered are derived from formations of Silurian, Devonian, Mississippian, and Pennsylvanian age.

Certain inherent weaknesses in methods of analysis are pointed out, particularly those for determining the SO_4 and HCO_3 radicles.

By plotting the percentage of sodium against the total solids, it is shown that there has been a relative loss of sodium in those brines that contain more than 140,000 p.p.m. of total solids. This loss is probably caused by fractional precipitation of NaCl (halite). The apparent optimum range in concentration of total solids for determining a "normal" water is 30,000 to 140,000 p.p.m. A mean analysis of a "normal" water is established within this range in concentration.

The mean analysis of connate water is compared with that of present-day ocean water. Assuming that the connate water was, in the main, derived from ocean water, it is possible to account for the apparent changes by logical chemical reactions under normal geologic conditions.

The conclusion is reached that the chemical composition of the Carboniferous sea was probably similar to that of present-day sea water.

The geographic distribution of certain ions is shown by means of maps, and factors affecting the concentration of the waters are discussed. Attention is called to several reactions that may be of prime importance in the origin of oil and gas and certain cements in producing formations.

CRETACEOUS-TERTIARY RELATIONSHIPS IN NORTHERN SOUTH AMERICA

BY HOLLIS D. HEDBERG

Cretaceous-Tertiary relationships in northern South America are not yet entirely clear. Review of a number of sections in Trinidad, Venezuela, Colombia, and the coastal islands shows a general tendency toward shallowing of seas and even emergence near the close of the Cretaceous; one or more major unconformities everywhere intervene between uppermost Cretaceous and very late Eocene deposits. However, shallow-water Cretaceous-Paleocene transitions appear to exist in many places, and locally there is evidence of essentially continuous deposition through Cretaceous, Paleocene, and much of Eocene time. Major orogeny appears to have occurred within early Tertiary time rather than at the Cretaceous-Tertiary boundary.

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Final solution of Cretaceous-Tertiary relationships must await determination of more reliable paleontological criteria of the two systems for this particular region.

APPALACHIAN PERIDOTITE BELT: ITS SIGNIFICANCE IN SEQUENCE OF EVENTS IN MOUNTAIN BUILDING

BY H. H. HESS

A double row of small peridotite masses, intruded during the Taconic Revolution, extends from Newfoundland to Alabama. Every mountain system of the Alpine type contains serpentinized peridotites along its axis of most intense deformation. This type of peridotite is not found except in connection with mountain systems. It is intruded only during the first great deformation forming the system. It is the product of crystallization of a hydrous peridotite magma.

Using the peridotites as a guide to the axis of a system and examining mountain structures of varying degrees of development and dissection, a series of horizontal planes may be visualized cutting mountain structures at progressively lower levels. For such a study the following may be suggested: (1) West Indies, mountain system not yet elevated; (2) Alps, recently elevated; (3) Appalachians, dissected to moderate depth; (4) Canadian Shield, Archean, dissected to great depth. A fifth level, the bottom of the crust, may be postulated from gravity anomalies in island arcs.

Re-examining the Appalachians with this broad picture of mountain structure in mind drastic rearrangement of prevailing ideas seems necessary: (1) Cambro-Ordovician stratigraphy indicates sedimentation in a sea marginal to a continent (moderately deep water shale, limestone); (2) a great Taconic Revolution produced an island arc along the present Piedmont belt (volcanism on Atlantic side, peridotite intrusions); (3) geosyncline is developed between arc and continent which received rapid, coarse clastic, shallow water sediments (Siluro-Devonian); (4) subsequent deformations fold the geosynclinal sediments.

Mountain building came first; the geosyncline developed as a result not only in the Appalachians but in every mountain system. Perhaps no greater misconception exists in geology than that geosynclines localize mountain building. The Appalachian geosyncline was folded in the late Paleozoic much as was the equivalent zone of the Jura in the Alps. This happens to be the most evident feature of the present Appalachians, but it represents not the great revolution but the last and dying phase of a series of Paleozoic deformations.

GREENLAND AS AN AMERICAN OUTPOST

BY WILLIAM HERBERT HOBBS

The occupation and subjection of Denmark by Nazi Germany has made Greenland a country over which the United States may exercise sovereignty under application of the Act of Havana. Its strategic importance to the United States is large in supplying naval and air bases, somewhat limited though these are by remoteness and by unusual physical conditions.

HYDRO-PHYSICAL APPROACH TO QUANTITATIVE MORPHOLOGY OF DRAINAGE BASINS

BY ROBERT E. HORTON

The purpose of this paper is to show how fundamental principles of physics, hydraulics, and hydrology may be applied quantitatively to the study of drainage basins and their stream systems.

As a basis for this study, numerical factors are needed which characterize the physical features of a drainage basin and its stream net quantitatively. Particular stress is laid on two closely related factors, drainage density and infiltration-capacity, as indicative of degree and rate of basin and channel development.

Except in regions of karst topography, stream basin development by aqueous erosion is conditioned almost wholly by surface runoff, exclusive of ground-water flow. The independent physical variables controlling surface runoff are: rain intensity, rain duration and intensity distribution, infiltration-capacity, surface roughness, surface slope, length of overland flow, and type of overland flow. These factors, in conjunction with the hydraulic laws of sheet flow (Manning's formula for turbulent, Poiseuille's formula for laminar, flow), together with the law of continuity, afford a basis for a complete rational treatment of surface runoff phenomena. Hence the purely hydraulic and hydrologic phases of the subject may be considered as completely solved.

The second phase of the subject—determination of the rate of sheet erosion corresponding to a given surface runoff regimen— is almost as completely unsolved. Assuming merely that for a given drainage basin sheet erosion is a function of hydrologic conditions, conclusions can be drawn which are helpful in understanding the physiographic characteristics of drainage basins and their drainage nets.

GEOLOGICAL MUSEUM OF THE FUTURE

BY B. F. HOWELL

Geological museums have in the past usually been dead and gloomy places. Those of the future will be filled with brightly colored specimens and restorations with artistic labels and with some exhibits illustrating geological phenomena that actually move. Paintings and three-dimensional restorations of the life of past periods, models of volcanoes, lighted from within so that they seem to be in action, geological "time clocks" that run, and series of dioramas which succeed each other in the visitor's view, as well as revolving exhibits of various sorts, will add life and interest for the visitor. Motion pictures which explain and supplement the other exhibits will make intelligible to the public geological phenomena and historic events which could not be made vivid in any other way. The geological museum of the future will be as popular as any other scientific museum.

ILLINOIAN GLACIATION IN KILLBUCK VALLEY SOUTH OF MILLERSBURG, OHIO

BY GEORGE D. HUBBARD

Scattered remnants of much-weathered glacial drift found down Killbuck Valley for 4 or 5 miles below the late Wisconsin drift border at Millersburg, clinging to the valley walls above the outwash, and below numerous sliding local sandstone boulders, indicate that an Illinoian valley dependency on the margin of the Illinoian ice sheet extended this far down the valley. The Illinoian drift sheet seems to have been completely overridden by Wisconsin ice in this region although considerable areas of it are exposed a few miles farther west.

In the valley are a dozen remnants of outwash terraces strung along the Killbuck River to its mouth and probably far beyond. Some of these are carved into two or three steps, some have cusps and crescentic fronts carved on their valley margins. These details, and the even slope of the terrace tops, with their similarity in height on opposite sides of the valley, lead to the belief that the valley was once filled entirely to the height of the terrace tops. Deep erosion, cementation, and much weathering

of pebbles in the outwash argue that it is Illinoian. Its extensive removal is believed to have been accomplished by pre-Wisconsin erosion. Nothing of truly fresh Wisconsin outwash or drift is known in the valley below the immediate vicinity of Millersburg.

FURTHER OBSERVATIONS ON THE LOWER PALEOZOIC SEQUENCE OF WESTERN NEWFOUNDLAND

BY HELGI JOHNSON

The Lower Cambrian Labrador group is discussed and a new formation is recognized in its sequence which can be correlated with strata in southeastern Newfoundland, as well as with North American lower Cambrian formations.

An extension of the shelly limestone facies of the lower Ordovician of eastern North America is exceptionally well developed, but with it is intermingled an almost complete, though badly broken up, shale facies resembling the Levis graptolitic shales and the Schacticoke, Deepkill, and a portion of the Normanskill shales of the Northern Appalachian province.

The present distribution of the latter formations is explained by low-angle thrust faulting which has carried these beds westward for considerable distances. Later high-angle thrusts have brought up pre-Cambrian rocks and repeated the Cambrian and Ordovician strata.

Interesting graptolite faunas have been collected and partially studied. These not only show close affinities to the Levis and New York State assemblages but also contain species more closely related to those of the British Isles and Scandinavia. An *Isograptus* faunule resembles forms in the Castlemain of Australia.

COMPOSITION AND STRUCTURE OF THE COASTAL PLAIN IN NEW JERSEY

BY MEREDITH E. JOHNSON

Previous workers have described the Cretaceous and Tertiary formations of New Jersey as they appear in outcrop and have published geologic sections showing that these dip gently to the southeast at uniform rates ranging from only a few feet per mile for the youngest strata to a maximum of "40 to 50 feet to the mile". This paper presents data which show that the character of the strata changes markedly down the dip and that the structure of the unconsolidated strata is not so uniform as had been supposed.

VALIDITY OF FOUR ADDITIONAL CLASSES OF ARCUATE STRUCTURES

BY ASHTON KEITH

Geological literature indicates that the term "arcuate" has been applied only to one general kind of oxbow structure— namely, the positive or uplift forms, such as curved mountain ranges and island arcs. Four other classes of arcuate forms may be recognized:

(1) Negative Arcuates: Studies of several areas of crustal downthrow have established borders in which the well-known scallop pattern of overlapping arcs is almost as clearly evident as in the classic examples along Asia's eastern coast.

(2) Mixed Arcuates: The arcuate trend of certain mountain ranges which end abruptly has been found to be continued by a long zone of strong faulting of complementary curve.

(3) Compound Arcuates: A volcanic mountain range convex toward the north gives way to a long line of volcanic islands of reversed curve.

(4) Complex Arcuates: A vast arcuate zone of strong negative anomalies in Malaysia is found to include smaller arcuate structures of divers orientations.

GENETIC HISTORY OF PEGMATITES AND ASSOCIATED ROCKS OF THE CAROLINA TIN BELT

BY THOMAS L. KESLER

The south-central portion of the Piedmont province in North Carolina contains a northeast-oriented belt of spodumene-bearing pegmatites closely associated with deposits of cassiterite. The belt, which parallels the strike of the country rocks, has a maximum width of 1.8 miles and a length of 25 miles, extending half a mile into South Carolina. Generally similar pegmatites occur beyond the confines of this belt, but, with the exception of two gem localities, spodumene is not found elsewhere and serves to delimit the area discussed.

Wallrocks of the pegmatites dip steeply northwest and comprise nine distinct groups exclusive of post-pegmatite diabase. There is considerable range of relative composition and texture within some of the groups, particularly the amphibole and highly feldspathic gneisses. They have an essentially monoclinal structure and represent sedimentary rocks that were folded and reconstituted under hydrothermal influence. The pegmatites were formed by locally concentrated hydrothermal solutions that were introduced for the most part after reconstitution of the wallrocks. The lack of rigid confinement of the successive solutions that formed the pegmatites makes it essential that both wallrocks and pegmatites be studied carefully for an adequate genetic history of either.

APPALACHIAN OROGENY AND SEDIMENTATION

BY PAUL D. KRYNINE

The petrographic study of a fairly complete suite of Paleozoic sediments from central and western Pennsylvania resulted in the division of all Paleozoic formations into four recurring lithologic units: (1) graywackes and shales, (2) quartzitic sandstones, (3) chemical and organic precipitates, (4) unusual clastics like calc-arenites. It is shown that identical rock types recurring throughout the Paleozoic section were formed through the reworking of similar pre-existing older Paleozoic sediments. The Tuscarora quartzite is made of Cambrian quartzites, and the Chemung graywackes were derived from more than nine different sources with a predominance of Middle Ordovician and Lower Devonian elements. These conclusions are based on thorough studies of heavy-mineral assemblages and character of bulk constituents.

It follows that older Paleozoic formations have been repeatedly re-elevated into the zone of erosion beginning with the Upper Cambrian. Hence it is suggested that considerable deformation paralleled the building of the Appalachian Geosyncline. This diastrophic process shows three orders of magnitude: (1) the main steady downsinking of the trough; (2) large-scale recurrent tilting and flexing involving large areas, mostly in the eastern part of the trough, and bringing into the zone of erosion many of the older Paleozoics of eastern Pennsylvania; (3) widely distributed local anticlinal folding, possibly "semi-traveling" after the Dutch East India pattern. This third-order orogeny covered the geosyncline with many Paleozoic structures, even far to the west. Erosional truncation of these structures kept pace with folding, forming on their flanks a remarkable series of intraformational locally derived clastic sediments ranging from conglomerates to dolomite-arenites. The Nittany Arch is a conspicuous example. The final Permian folding only followed these Paleozoic zones of weakness, rejuvenating the ancient structures.

GRAVITY VERSUS "VOLATILE TRANSFER" DIFFERENTIATION AND CONNATE WATERS

BY ALFRED C. LANE

Papers by F. Walker and Schwartz and Sandberg in the 1940 Bulletin of the Geological Society of America treat magmatic differentiation in basaltic sills and confirm previous work by E. S. Moore, Sidney Powers and A. C. Lane, and T. M. Broderick on the gravitative effects by which olivine and pyroxene tend to settle, though the quickly chilled and extreme base is of medium composition. They show up hydrothermal effects, grading from acid interstices to various doleritic, pegmatitic, aplitic "redrock" and granitic fractions.

They are not inconsistent with what Broderick has emphasized, that the iron does not entirely follow the magnesia by "volatile transfer", is carried up, probably as chloride, with the copper and presumably the uranium also.

Besides looking to some such action for the origin of the granitic layer, and the greater amount of uranium in the upper crust, we may also look to escaping chlorine as the source for the ocean, and the connate salt waters.

Chlorine will not have been so largely combined with sodium as at present, for through leaching of the land surface sodium carbonate, silicate or sulphate will react on the original part which was calcium and magnesium; and especially in the case of a nonoxidizing atmosphere, ferrous chloride, and cherty ferrodolomites and jaspilites will be precipitated and the sodium chloride relatively accumulate, except when salt has been precipitated, leaving bitterns.

The original ratio of Na:Cl was less than 0.07.

PHYSICAL FRONTIERS IN SEISMOLOGY

BY L. DON LEET

Seismology has reached a critical stage where serious discrepancies between observations and current theories have been established. Investigation of these is awaiting the interest and abilities of mathematical and experimental physicists. It is believed that solutions will lead to results of geological importance in connection with data on the structure of the earth's crust, mantle, and core.

Over a year ago, the writer reported observations of a new wave form, tentatively called the Coupled Wave, which is not explained by the classical theory of elasticity. It was first found in the vicinity of dynamite blasts and in some cases dominated the motion. Subsequent search by Collins on earthquake records at the Harvard Seismograph Station revealed it at certain distances as the wave which had previously been called the Shear Wave of classical theory. This led further to the discovery that the so-called Shear Wave is actually compressional over certain distance ranges, a Coupled Wave over others, and shows the characteristics of a true Shear Wave over only a relatively narrow range.

Birch has made one of the first fundamental attacks on these widening physical frontiers in seismology by investigating the effect of pressure upon elastic parameters of isotropic solids, according to Murnaghan's theory of finite strain. He suggests "that a more rigorous solution of the equations of motion derived from the theory of finite strain might prove of value in interpreting the oscillatory character of seismic records, as well as the direction of the ground motion associated with various wave types."

PROBLEMS OF OROGENY

BY CHESTER R. LONGWELL

Orogeny is defined as large-scale crustal deformation characterized by folding, thrusting, and other evidences of compression. The chief objectives in the study of orogenic structures are: (1) To determine the geometric pattern of features that record deformation in the several orogenic zones. The first step to this end is accurate mapping of mountain belts, but even if this part of the task were fully accomplished the third dimension would still present large uncertainties—the depth to which deformation extends and the nature of deformation at all depths below the zone of observation. Some attempts to calculate depth of deformation from surficial evidence have reached questionable conclusions. (2) To establish the nature of stresses responsible for the several kinds of deformation in orogenic zones. The stresses are to be inferred from the field facts, with the assistance of laboratory experiments, particularly experiments using scale models. (3) To date the orogenic events as closely as possible. The development of any one zone can be understood only after the correct order of events in that zone is determined. Exact dating of all orogenic movements would go far toward settling the controversy as to whether diastrophism is "periodic" and "worldwide" in character. (4) To detect the ultimate forces responsible for diastrophism. This subject is still in the speculative stage and can be approached only by the method of multiple working hypotheses.

A comprehensive study of orogeny must consider its relation to the other kinds of crustal deformation—major warping, or epeirogeny, and regional block-faulting, sometimes designated tafrogeny.

PRE-RARITAN RIVER GRAVELS IN THE RARITAN VALLEY, NEW JERSEY

BY JOHN B. LUCKE

The idea that some master stream of the Appalachian slope once traversed northern New Jersey has been proposed by Davis, Johnson, and others, largely on the basis of map and profile studies. The present paper endeavors to test such hypotheses by examination of gravel deposits in the Raritan Valley near New Brunswick, New Jersey.

In the vicinity of the Fall Zone at least six exposures reveal beds of coarse, well-rounded stream gravels differing markedly from the typical "Pensauken formation" with which they have heretofore been mapped. Field relationship of these exposures to the present Raritan River, the Pensauken formation, and to each other is described. "Pebble counts" of the boulders and cobbles invariably indicate a high content (50 to 75 per cent) of white, tough quartzite and quartzitic sandstone together with an appreciable fraction (15 to 30 per cent) of milky to clear rock quartz. Rocks commonly outcropping in the watershed of the present Raritan River are strikingly scarce. The large size of the particles (maximum diameters of 15 inches are not rare) also suggests deposition by a former large stream, draining an area foreign to northern New Jersey.

The described field data, while regarded as evidence of a pre-Raritan river in the present Raritan Valley, do not permit decisive judgment as to the relationship between such an ancestral stream and modern Appalachian drainage. The evidence may serve as a contribution toward such a determination and also as a "progress report" in the deciphering of the complex Pensauken formation.

MARINE TOPOGRAPHY OF THE CAPE MAY FORMATION

BY PAUL MAC CLINTOCK

The Cape May formation of New Jersey is a late Pleistocene accumulation of sand and gravel deposited when sea level stood a score or more feet above that of today. The seaward part of the formation, containing here and there fossils, is marine, whereas valley deposits to the landward, contemporaneous in age, are fluvial. The formation was first considered to be Wisconsin in age because it contains erratic stones, but more recently it has been considered as nonglacial because it was deposited during a high stand of the sea and because it contains warm-water fossils—*i.e.*, as either interglacial or early postglacial during a temperature maximum. The present study approaches the question of age by an analysis of the topography of the marine portion of the Cape May formation. It is found to be that of low bars and shallow longitudinal depressions, parallel to the present shore, drained and slightly modified by consequent fluvial erosion. From the evidence of the amount of erosion of the constructional topography the marine part of the formation may be rather confidently referred to the last great interglacial interval—*i.e.*, the Sangamon. Furthermore, sea level has not been higher than its present stand since this interglacial time.

COMPLEX STRUCTURES OF THE NEW RIVER BASIN

BY A. A. L. MATHEWS

Complex structures associated with the major thrust faults of the New River Basin are described, and their origin and significance are discussed. An account is also given of the topography which results from these structures.

RELIEF REGIONS OF TYOSEN (KOREA)

BY SHANNON MC CUNE

The mountainous relief of Tyosen (Korea) plays an important role in the life of the people. Upon the basis of Japanese, other source material, and field observation the peninsula has been subdivided into 14 regions; in this paper the regions are discussed both in regard to their relief features and to their human occupancy. The more mountainous northern part of the country has been divided into five regions: the northern interior, the Tumen basin, the northeastern coastal hills and valleys, the northwestern hills and plains, and the north-central mountain core. This area is separated from less mountainous southern Tyosen by the Gensan-Keizyo graben. Southern Tyosen is subdivided into six regions: the Taihaku block, the eastern coastal hills and valleys, the western hills and plains, the southern mountains, the southeastern hills and valleys, and the embayed southern littoral. Finally there are two volcanic islands; Sanisyu (Quelpart) and Uturyo (Dagelet). A physiographic diagram and photographs will be shown.

ASSOCIATION OF PYROXENE GRANITE AND SERPENTINE NEAR LIMA, PENNSYLVANIA

BY ADOLPH E. MEIER

The purpose of the work has been: (1) to work out the areal geology of this complex in greater detail than has been done before; and (2) to make a detailed study of serpentine granite contacts by chemical and petrographic analysis in order to discover,

if possible, any connection between assimilation of ultrabasic by granite magma, and the genesis of the highly feldspathic dikes (some rich in oligoclasic albite of the "moonstone" variety, others containing more calcic plagioclase and corundum) found within the area.

The data on changes in magnesia and silica content which take place in the granite as a serpentine contact is approached are not yet complete. They will be presented for discussion in more complete detail, together with an interpretation by the author if the results seem to justify one.

EVIDENCE OF SULFIDE-SILICATE IMMISCIBILITY

BY LOUIS MOYD

From the old Gap Nickel Mine in Lancaster County, Pennsylvania, field evidence indicates sulfide-silicate immiscibility in the magma. Pyrite, chalcopyrite, pyrrhotite, and pentlandite form a layer 30 feet thick at the periphery of an ultrabasic sill infolded in the Baltimore gneiss. The ore diminishes gradually into the amphibolite but is completely absent from the schistose country rock. In the ore are rounded masses of hornblende, about an inch in diameter. If these nodules are considered the crystallized remnants of once-liquid silicate globules suspended in fluid sulfide, a simple interpretation of the body as a normal gravitative sulfide deposit is derived from the evidence.

The following genesis of the ore body is suggested. At high temperature a small basic laccolith was intruded into the Baltimore gneiss. As the magma cooled, sulfide and silicate became less soluble in each other and began to separate, the sulfide being carried to the bottom. With continued cooling, increasing viscosity retarded gravity-influenced migration of the components, causing the sulfide separating from solution in the upper levels to be trapped in the silicate, and the silicate coming out of solution in the lower zone to form globules in the fluid sulfide matrix. The silicate crystallized, but with interstitial and underlying sulfide still fluid. At this stage, the body was subjected to regional stresses, which buckled it into its present lens form. The fluid sulfide penetrated the fractures, forming a structure similar to that caused by metasomatic processes.

REFLECTANCE OF OPAQUE MINERALS

BY WILLIAM PARRISH

This paper discusses how the reflectance of opaque minerals in polished sections can be measured rapidly under the microscope and used for identification purposes in a manner analogous to the use of refractive indices in identifying nonopaque minerals. The optical phenomena are reviewed. The following data can be determined from reflectance measurements when normally incident plane polarized light is used: R of an isotropic crystal (corresponding to n of the nonopaques); R_o and R_e, the principal reflectances of a uniaxial crystal (corresponding to n_o and n_e); R_o-R_e, the bireflectance (corresponding to the birefringence); maximum and minimum reflectances of a random section, R_2 and R_1; optical sign of a uniaxial crystal; the principal reflectances R_g, R_m, R_p, and the bireflectance R_g-R_p of biaxial crystals. Dispersion and color can be determined from reflectance measurements in monochromatic light. A quantitative measurement of the anisotropic effect between crossed nicols is possible only in monochromatic light. Reproducible reflectance values can be obtained if reasonable care is exercised in preparing the polished sec-

tions and in setting up the apparatus. Standard light sources, filters, photoelectric cells, comparison standards, and various techniques for measuring reflectance were critically studied. The reflectance of about 200 minerals for various wave lengths and orientations have been compiled from the literature and the writer's measurements, but the data are insufficient for the preparation of identification tables; many more measurements are needed, especially on oriented sections and uncommon species. A number of color measurements were obtained with the Hardy Color Analyzer.

DISTRIBUTION OF PETERSBURG GRANITE IN SOUTHEASTERN PIEDMONT, VIRGINIA*

BY A. A. PEGAU

This paper discusses the distribution in southeastern Piedmont Virginia of Petersburg granite which was mapped by the author under the sponsorship of the Virginia Geological Survey and the Virginia Academy of Science. The field investigations were made during the summers of 1931, 1937, and 1939.

The area mapped extends from the Southanna River on the north to the North Carolina boundary on the south, a distance of 85 miles. The most easterly outcrops occur along a line that runs due north and south through Petersburg, whereas the most westerly granite boundary is 33 miles due west of this line.

Detailed mapping has shown that the Petersburg granite occurs not as a single body within the limits of the area mapped but as three distinct units. The easternmost unit is covered in large part by Cretaceous and Tertiary Coastal Plain sediments on the east and by Triassic sediments along its western boundary. This body crosses from north to south parts of Hanover, Henrico, Chesterfield, Dinwiddie, and Sussex counties. The second unit or belt is confined largely to Brunswick and Greensville counties. It is surrounded by pre-Cambrian schist and gneisses except for a short distance along its southeastern border. The third body, lying completely within pre-Cambrian rocks, underlies parts of Dinwiddie, Nottoway, and Brunswick counties.

GEOGRAPHICAL MATERIALS IN LIBRARIES OF THE UNITED STATES WITH ESPECIAL REFERENCE TO NATIONAL DEFENSE

BY ELIZABETH T. PLATT

This paper briefly describes the Special Libraries Association Defense Program and discusses some of the major library collections from the geographer's point of view. Especial emphasis is placed on guides to locating them.

GRANITIC ROCKS OF THE PHILADELPHIA AREA

BY A. WILLIAMS POSTEL

The igneous rocks in the Wissahickon schist in the Philadelphia region owe their origin to two types of magmatic activity: definite magmatic intrusions into the Wissahickon schist, and hydrothermal replacement of the Wissahickon schist by potash and soda-rich solutions. The metagabbro, the Springfield aplitic granodiorite, and the Ridley Park granodiorite are the products of magmatic intrusion. The Springfield porphyroblastic granodiorite is the product of hydrothermal reaction with, and replacement of, the Wissahickon schist.

No precise chronological position can be assigned to the igneous rocks as the age of the Wissahickon schist is in doubt. Relative age sequence for the igneous rocks

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may be given as follows, from oldest to youngest: metagabbro, Springfield porphyroblastic granodiorite, Springfield aplitic granodiorite, and Ridley Park granodiorite.

The structure of the region, which includes the Wissahickon schist and its replaced member, the Springfield porphyroblastic granodiorite, is a gentle dome south of Philadelphia. The dome passes progressively through open folds to tight isoclinal folds to the north, northwest, and west.

IGNEOUS ROCKS OF THE WINNIPESAUKEE REGION OF NEW HAMPSHIRE

BY ALONZO QUINN

The oldest rocks of the Winnipesaukee region of New Hampshire and contorted schist and lime-silicate rock, both sedimentary and probably early Devonian. Younger than these metamorphic rocks are igneous rocks of two groups—the New Hampshire magma series of probable late Devonian age and the White Mountain magma series of possible Carboniferous age.

The rocks of the New Hampshire magma series are in large intrusions and include, from oldest to youngest, the Meredith porphyritic granite, the Winnipesaukee quartz diorite, and the Concord granite. The faint foliation of the Winnipesaukee quartz diorite, in particular, and the somewhat concordant relationships of these intrusions to the schist indicate that they were intruded during a late stage of the metamorphism of the schist.

The rocks of the White Mountain magma series are characteristically in small extrusions and intrusions grouped together in rather small areas. Such areas as the Ossipee Mountains, the Belknap Mountains, and Red Hill have already been described. In addition, there are areas hitherto undescribed, such as the area of syenite at the Rattlesnakes, the granite mass at Green Mountain, and the Copple Crown-Merrymeeting Lake area which has considerable variety of rocks. Rock types present in these six areas include gabbro, diorite, monzodiorite, syenite, nepheline-sodalite syenite, quartz syenite, granite, and several dike rocks. The great variety of rock types indicates considerable differentiation of this magma. The intrusions are mainly pluglike masses or ring-dikes. They appear to have come in during a state of tension.

MARINE PLEISTOCENE MOLLUSKS FROM THE EAST COAST OF NORTH AMERICA

BY HORACE G. RICHARDS

During the past few years the writer has collected Pleistocene fossils from almost every important fossil locality along the east coast of North America between Hudson Bay and Mexico. Various lists of these fossils have been published together with remarks on the stratigraphy of the Pleistocene and on the correlation of the fossils. A summary of this work was presented at the Richmond meeting of Section E in December 1938.

These collections are now being assembled with a view to preparing an illustrated report on the fauna. Two distinct phases of the Pleistocene may be recognized by the fossils: (1) a cold fauna laid down in late- or post-Wisconsin time along the coast of New England and eastern Canada, and (2) a milder fauna found in the terrace deposits of the Atlantic and Gulf Coastal Plain between New Jersey and Texas. The majority of these latter fossils can be correlated with the Pamlico formation of Sangamon interglacial age.

The writer's most recent work on the marine Pleistocene consisted of a field trip along the west coast of Hudson Bay during the summer of 1940. Marine Pleistocene

fossils were found at numerous places between Churchill, Manitoba, and Chesterfield Inlet, North West Territories, and as far inland as Baker Lake, about 220 miles up Chesterfield Inlet northwest of Hudson Bay. These fossils clearly show a post-Wisconsin rise of the land which is probably still continuing.

STRATEGIC PROBLEMS OF AMERICAN DEFENSE

BY HERBERT ROSINSKI

Attempts to analyze the strategic position of the United States commonly suffer from the defect of considering that position by itself alone, without reference to the strategic structure of the world as a whole. In order, therefore, to gain a truly adequate appreciation of the problems facing American defense, it will be necessary to go back to the first really comprehensive analysis of world strategy, given by Admiral Mahan around the turn of the century, and to follow the changes in that conception reflected in Mahan's own later works, in those of Sir Halford Mackinder, and in the writings of General Haushofer. In retracing thus the genesis of the ideas inspiring Adolf Hitler's world-wide drive against the Anglo-Saxon democracies, inaugurated by the tripartite military alliance, it will be possible to estimate the defensive problems of the United States in the light of the very conceptions determining the nature and lines of the attack which they may have to face.

RESULTS OF A RESTUDY OF THE MOLLUSKS OF THE CALVERT AND CHOPTANK MIOCENE IN MARYLAND

BY LOIS M. SCHOONOVER

Stratigraphic and faunal restudy of the upper Calvert and Choptank formations of the Maryland Miocene has resulted in more detailed information concerning the occurrence and range of the common molluscan species than has hitherto been published. Little work has been done on the Maryland Miocene since the publication of the Miocene report of the Maryland Geological Survey in 1904, and little detailed information as to the stratigraphic range of species was given in that report.

Many of the zones recognized by Shattuck and the Maryland Geological Survey are not true paleontologic zones, but rather beds. Four, and possibly five, paleontologic zones are recognized. These zones are known principally from a linear section along the west shore of Chesapeake Bay and have been identified inland at only a few localities.

Differences in areal and stratigraphic distribution of individual species and areal and stratigraphic variations in the forms themselves are noted. Large suites of specimens of a single species from different beds and different localities have been studied in detail. In numerous cases a given species varies sufficiently areally or stratigraphically, or both, to enable one to recognize from what horizon and locality the suite has come. This is possible for suites of specimens, but usually not for individual specimens.

Several species of mollusks are commonly preserved in colonies in their living position, and one such colony of echinoids has been found.

CRETACEOUS-TERTIARY RELATIONSHIPS IN THE COASTAL PLAINS AREA OF TEXAS

BY GAYLE SCOTT

This paper reviews the strata involved in the Cretaceous-Tertiary contact in the Gulf Coastal Plain with particular reference to Texas. Age and intercontinental correlation of the Navarro and Midway groups are discussed. An attempt is made

to demonstrate the extent of the hiatus between the Navarro (and equivalent beds) and the Midway. Evidence shows that the Midway is more closely related to the Cretaceous.

Lithologic, stratigraphic and diastrophic, and faunal and floral criteria are evaluated. Midway lithology is more similar to underlying Navarro than to overlying nonmarine Wilcox. Graphs and emergence and submergence data suggest a Midway depositional history closely comparable to that of the Danian in Scandinavia and indicate that the great hiatus of marine deposition follows, rather than precedes, the Midway epoch.

Midway fossils, except the corals, are more closely related to known Cretaceous than to Tertiary faunas. Molluscan species are most useful in correlation, and comparisons of species are given.

The following conclusions are offered: (1) Species of the group of *Hercoglossa ulrichi* of lower Midway are closely similar to *Hercoglossa danica* of lower Danian and indicate a lower Danian age; (2) *Venericardia* (group of *V. bulla*) similar to the Danian *V. beaumonti* in the middle and the upper Midway indicate a middle and upper Danian age; (3) stratigraphy and diastrophism confirm these correlations; (4) topmost Navarro is upper Maestrichtian in age; (5) the hiatus between Navarro and Midway is confined to latest Maestrichtian and earliest Danian; (6) the Midway fauna is an impoverished Cretaceous fauna in which some Tertiary elements make their appearance; (7) the Midway should be placed in the Cretaceous, and the Cretaceous-Eocene contact lies at the level where Midway marine deposition ended.

SUBMARINE PHYSIOGRAPHIC TYPES

BY PAUL A. SMITH

Modern sounding and hydrographic surveying methods make it possible to identify distinct physiographic types in well-surveyed submarine regions. Submerged mountain ranges, volcanoes, atolls, plains, plateaus, valleys, hills, and canyons, as well as more detailed features such as submerged river deltas, glacial troughs, giant sand waves similar to sand dunes on land, tectonic features, faulting, erosion features, and in general many of the forms commonly known on land, may be recognized from the detailed surveys of continental borders now being made, illustrated by examples selected from the Gulf of Alaska, Bering Sea, Philippine Islands, Atlantic and Pacific coasts of the United States, North Sea, Gulf of Mexico, Gulf of Maine, Nantucket Shoals, and Carolina coasts.

Of all submarine features, canyons and valleys have received the most attention in recent years, because of their significance in the relation between continents and ocean basins. The positions and characteristics of a number of the canyons in widely separated parts of the world are intimately related physiographically to existing land drainage. Several outstanding examples are discussed.

FURTHER EVIDENCE OF READING OVERTHRUST

BY GEORGE W. STOSE AND ANNA J. STOSE

The interpretation of the structure of the Reading Hills as a dissected overthrust plate composed of pre-Cambrian gneisses and faulted synclines of Cambrian quartzite is extended eastward into the Allentown quadrangle. The application of this interpretation is believed to clear up the apparent chaotic structure of that area. The gravity determinations across the region show a marked gravity depression which does

not support the interpretation that the pre-Cambrian rocks of the mountains are rooted in the crystalline basement and favor the overthrust theory.

GEOCHEMICAL DATA ON SARATOGA MINERAL WATERS

BY LESTER W. STROCK

Geochemical study of the mineral waters of Saratoga Springs has been begun by making systematic determination of minor constituents in the waters by quantitative spectrochemical and radioactive methods. Their origin is sought in the formations of the surrounding region, especially by an analysis of trace elements and characteristic assemblages of trace elements. The results of laboratory experiments on the processes involved in the leaching of rocks by waters rich in bicarbonic acid and alkali chlorides are expected to supplement new analytical data in providing a broader experimental basis for explaining the origin of mineral springs of the Saratoga type.

Zirconium (0.35 mg/L) is enriched in Saratoga mineral waters relative to iron as compared with the average composition of the earth's lithosphere. The related elements titanium and vanadium are simultaneously depleted. The ratios of these three elements to iron are:

	Lithosphere	Saratoga Water	Relative Enrichment
Fe : Ti	11.4 : 1	2000 : 1	0.0057
Fe : V	367.0 : 1	2000 : 1	0.18
Fe : Zr	227.0 : 1	8.5 : 1	27.0

Enrichment of tin parallels that of zirconium, with a ratio Fe : Sn = 96 : 1 representing 0.032 mg. tin per liter. Manganese, cobalt, and nickel, like titanium and vanadium, are depleted by a factor of approximately 20 compared with the lithosphere.

The mineral waters of Saratoga are thus products of selective enrichment or are themselves agents active in effecting selective removal of minor, as well as major, constituents of rock and mineral deposits. Work on other elements is still in progress.

SILURIAN OF THE CENTRAL APPALACHIANS

BY CHARLES K. SWARTZ AND FRANK M. SWARTZ

The Central Appalachian area comprises two Silurian provinces: (1) central and southwestern, and (2) northeastern.

The authors will outline the stratigraphy, distribution, and faunas of the various Silurian formations of each province. Their faunal zones will be tabulated, and the range of the zones given.

The term Crabbottom sandstone is proposed for a thick-bedded, whitish sandstone at the base of the Wills Creek formation near Crabbottom, Virginia, 6½ miles northeast of Monterey, Highland County, Virginia, along the road leading from Strait Creek to Crabbottom. This sandstone rests upon the McKenzie formation near Driscol and Frost, West Virginia. It is widespread and apparently intertongues northward with the Bloomsburg beds at the base of the Wills Creek in western Maryland.

Certain problems will be stated and considered, insofar as time permits: (1) The relations of the Tuscarora and Clinton to the Shawangunk and Massanutten sandstones. Evidence will be given to indicate that the Silurian portion of the Massanutten sandstone, as formerly defined, is, like the Shawangunk, of combined Tuscarora and Clinton age. It is proposed to restrict the term Massanutten sandstone

to the Silurian beds. (2) The limits and correlation of the McKenzie formation. (3) The Keyser problem and the upper boundary of the Silurian.

TOPOGRAPHY OF THE MONTEREY, STAUNTON, AND HARRISONBURG QUADRANGLES

BY H. D. THOMPSON

This study was undertaken to observe some of the relations between topography and bedrock and to determine the number and positions of peneplanes in the Monterey, Staunton, and Harrisonburg quadrangles.

Altimetric curves of the summit areas and hypsographic curves of the entire surface were constructed. Pertinent data showing the relation of the bedrock to distribution of summits, altitudes of ridges, evenness of crestlines, flat tops, and steepness of slopes were tabulated.

Interpretation led to the following conclusions:

(1) Within the limits of weak rocks the Harrisburg peneplane is well developed in the Harrisonburg quadrangle, fairly well developed in the Staunton quadrangle, and poorly developed in the Monterey quadrangle.

(2) No peneplane above the Harrisburg is evidenced by the methods here used. Lack of clear evidence of the Schooley and/or other upland peneplanes in this region indicates either that they were never developed here or that they have been destroyed by subsequent erosion. Asymmetrical anticlines of resistant rock that were breached at high altitude exhibit a greater amount of differential lowering of the limbs than do similar anticlines breached at lower altitude, indicating that peneplanation has not occurred subsequent to the breaching of the anticlines.

(3) Considering the close relation between topography and bedrock and the inevitable truncation of deformed strata by long-continued erosion without peneplanation, the present topography can be explained satisfactorily without recourse to former planation of weak and resistant rock alike.

TRIASSIC DIKES OF BASALTIC GLASS AT SAFE HARBOR, PENNSYLVANIA

BY W. HAROLD TOMLINSON

Narrow basic dikes cutting across beds of Antietam gneiss, Vintage dolomite, and Conestoga limestone as exposed in quarries at Safe Harbor, Pennsylvania, are described and illustrated.

These dikes range in width from a quarter of an inch to 10 inches and in texture from porphyritic glasses through pitchstones to the fine-grained diabases. The order of crystallization is shown in dikes of different widths, and the effects of contacts are discussed.

CORRELATION OF LOWER EOCENE FORMATIONS OF NEW JERSEY AND ALABAMA

BY LYMAN TOULMIN, JR.

Correlation of the lower Eocene formations of the Atlantic Coastal Plain with those of the Gulf Coastal Plain has been difficult because very few species of fossils were found to be common to the two regions. A study of the Foraminifera of the Wilcox group of Alabama and the Vincentown formation (upper Rancocas group) of New Jersey indicates that this group of fossils affords better means of correlation than the larger fossils. Foraminifera corroborate the correlation of the Rancocas group with the lower Wilcox group.

The fauna of the Salt Mountain limestone (lower Wilcox) of Alabama is very similar to the fauna of the Vincentown formation. Not only are the faunal assem-

blages similar, which may indicate similar ecological conditions, but also a large number of the same species, particularly Foraminifera, are present in both formations, and several species are closely related to species in the other formation. Over 20 per cent of the species of Salt Mountain Foraminifera are present in the Vincentown. The Salt Mountain limestone, like the Vincentown, has a large bryozoan fauna, but it has not yet been described.

Inasmuch as the faunas of the Alabama Wilcox formations seem to be provincial faunas with limited geographical ranges, the Salt Mountain fauna may prove to be a key fauna enabling a closer correlation of the formations of the Atlantic Coastal Plain with those of the Gulf Coastal Plain.

RADIO-ELEMENTS IN WATER AND SEDIMENTS OF THE OCEAN

BY WILLIAM D. URRY

The radioactive relations existing in the ocean and its sediments are complex in comparison with the simple relations for the igneous and sedimentary rocks that form the continents. This is because neither in the ocean nor in the upper layers of the ocean bottom are elements such as uranium, ionium, and radium in radioactive equilibrium. In discussing the distribution of the radio-elements, the dimension of time is therefore of prime importance. The sediments underlying the deeper portions of the ocean provide suitable material, correlated with this dimension, for studying the growth and decay of these elements. Glacial and other stratifications in some of these sediments greatly complicate the radioactive relations. These studies indicate the possibility of establishing the rate of deposition of the ocean sediments.

COURSE ON THE GEOGRAPHY OF NATIONAL DEFENSE *

BY S. VAN VALKENBURG

The Department of Geography at Clark University offers a new course, called the Geography of National Defense, which is given by all (five) members of the department, each one in his special field. The department feels that an account of this course might be of interest to other colleges and, therefore, offers the outline as an example of what the geographer can do to contribute to the case of National Defense. An outline is as follows:

(1) The American territory, including possessions and bases. The factors of location, size, and shape.
(2) The boundaries of the United States.
(3) Climate as a factor in evaluation of the strength of the nation.
(4) Weather and war, including a study of weather maps.
(5) Construction and interpretation of topographic maps.
(6) Relief and shore configuration related to coastal defense.
(7) Physiography and war, the influence of terrain on warfare.
(8) Distribution and composition of population with regard to national and international policies.
(9) Agricultural policies in times of peace and war and their bearing upon defense.
(10) Land use, conservation, and planning in their relation to food supply and military equipment.
(11) Strategic raw materials.
(12) Manufacturing and National Defense.
(13) Transportation and National Defense.
(14) Special problems of trade.
(15) The outer possessions as a factor in National Defense.

PROBLEMS OF COAL DISTRIBUTION AND TRANSPORTATION IN WAR TIME

BY WALTER H. VOSKUIL

In the event of American participation in a war, transportation facilities will be heavily burdened, as was the case in the last World War, and some control measures over rail transportation may be essential. Since 35 per cent of all freight originating on railroads consists of anthracite, bituminous coal, and coke, the use of railroad facilities for the transportation of these materials may require rationing. Such a policy requires a careful analysis of existing coal movements with a view toward reducing or eliminating unnecessary long-distance movements and cross hauls. A series of maps show the existing patterns of coal movements in this country, by uses and by modes of transportation. Certain large tonnage movements such as the all-rail movement from the low-volatile fields to the Chicago market may be curtailed in the interest of transportation economy. Movements from southern Appalachian fields via tidewater to New England destinations may be curtailed to avoid undue congestion in Atlantic Seaboard ports.

SPITZENBERG CONGLOMERATE AS A TRIASSIC OUTLIER IN PENNSYLVANIA

BY LAWRENCE WHITCOMB

The Spitzenberg conglomerate caps the conical hill of that name near Greenawald on the Hamburg, Pennsylvania, topographic map. No other outcrop of similar rock has been found in the surrounding region. Although actual contacts are buried, the conglomerate seems to rest unconformably upon the Martinsburg shales, the conglomerate being in the form of a gently dipping spoon-shaped syncline, while the underlying Martinsburg is highly folded and has steep dips in all adjacent outcrops. The conglomerate includes beds of arkosic sandstone, shale, and conglomerate, cross-bedding is common, most beds are gray, but some are reddish. It is lithologically very similar to the Triassic fanglomerates of the Delaware Valley. No fossils have been found in the matrix or pebbles. The pebbles have been studied in an effort to determine their sources. While the Martinsburg and older formations do not seem to be lithologically capable of furnishing the pebbles there are numerous younger formations that could provide them. The location of the Spitzenberg in relation to the outcrops of these younger formations would require drainage from the north or west to bring the pebbles to their present location. Drainage in this direction is not believed to have existed in the Paleozoic, but it did exist in the Mesozoic. Fanglomerates are common in the Triassic, but unknown in the Paleozoic of this part of the country. Although no paleontologic proof is available the Triassic age seems to be the most likely. If the Spitzenberg conglomerate is a Triassic outlier it becomes highly significant in the discussion of Triassic sedimentation in Pennsylvania.

APPROPRIATE POLITICAL CONTROL OF THE NATION'S DEFENSE RESOURCES

BY DERWENT WHITTLESEY

The assumption is made that we have and wish to preserve a republican form of government. This raises the question as to how much control over the exploitation and consumption of natural resources ought to be exerted by government in peace time. If government control is desirable, which governmental agency shall be entrusted with it: the federal government or some local unit—State, county, city,

or other? Can governmental agencies play a suitable part in wise use of resources short of outright control? Are the answers given subject to change in the present need for quickly establishing national defense?

The foregoing questions are discussed in terms of specific groups of natural resources.

MARTINSBURG SEQUENCE IN LEHIGH COUNTY, PENNSYLVANIA

BY BRADFORD WILLARD

Northern Lehigh County, Pennsylvania, is underlain by several thousand feet of Upper Ordovician clastic sediments, the "Martinsburg." The beds strike approximately east-west in three bands, the middle sandstone, bordered by shale and slate. Two interpretations exist. Beginning with Rogers, 1836-1838, many call the sequence bipartite—shale below sandstone. This requires a broad synclinal structure with the sandstone axial. Others support a tripartite interpretation—shale, sandstone, shale, the structure monoclinal, north-dipping. Recent stratigraphic, paleontologic, structural, and geophysical studies appear to support the bipartite and refute the tripartite interpretation. The significance of the correct understanding of the "Martinsburg" sequence bears directly upon the structure, correlation, and age relations of the Ordovician "Slate Belt" of eastern Pennsylvania.

UPPER HELDERBERG-ORISKANY RELATIONS IN WEST VIRGINIA

BY HERBERT P. WOODWARD

Detailed study of the stratigraphic relations of lower Devonian rocks in West Virginia, sponsored by the West Virginia Geological Survey, has made available new data bearing upon the troublesome problems of upper Helderberg-Oriskany correlations and boundaries.

It has been possible at most exposures of the "Shriver" chert and "Becraft" (Licking Creek) limestone to identify successive faunal or lithologic zones correlative with the Port Ewen, Port Jervis, and so-called lower Oriskany (*Orbiculoidea jervensis*) zones of the eastern Pennsylvania-New Jersey area, indicating that most portions of the "Shriver" and "Becraft" of West Virginia are homotaxial or synchronous. No constant boundary has previously been used to separate the "Shriver" chert and Ridgeley sandstone. Whereas the *"Spirifer" arenosus* zone of the Appalachian area is mainly a sandstone universally recognized in the Ridgeley sandstone, the lower *"S." murchisoni* zone is locally nonarenaceous and is represented by cherty or calcareous beds that have sometimes been assigned to the "Shriver" chert, and sometimes to the Ridgeley sandstone. Hence, the stratigraphic and faunal content of the "Shriver" has not been constant. In at least one belt (the Great Cacapon Mountain area), the arenaceous facies elsewhere restricted mainly to the *"Spirifer" arenosus* zone descends well into the upper Helderberg, a fact that has been responsible for the unusual thicknesses assigned to the "Ridgeley" sandstone.

In southeastern West Virginia, the various members of the Helderberg group grow markedly arenaceous concurrently with the disappearance of the *"Spirifer" arenosus* and *"S." murchisoni* zones. Confusion of identification has resulted, with Helderberg sandstones reported as "Oriskany." It is suggested that this misidentification has been carried westward in studies of deep-well records in some of the gas fields of west-central West Virginia, and that much, if not all, of the so-called "Oriskany sand" of these wells is actually Helderberg.

MAGNETIC INVESTIGATIONS IN THE ATLANTIC COASTAL PLAIN

BY GEORGE P. WOOLLARD

Magnetic measurements in various parts of the Atlantic Coastal Plain indicate marked anomaly areas. Although these areas can in part be correlated with subsurface geologic phenomena from well data, for the most part they rely upon a comparison with other geophysical data for a geological interpretation.

In both New Jersey and Virginia certain areas are characterized by high magnetic values, high gravitational values, and high seismic velocities, and these are believed to be indicative of gabbroic type rocks. Conversely other areas are characterized by low magnetic values, low gravitational values, and low seismic velocities, and these are believed to indicate granitic types. In both States seismic depth data indicate no marked relief in the surface of the crystalline basement, and the magnetic and gravitational anomalies are therefore presumably related to lithologic variations in the "basement."

A test magnetic profile across the exposed crystalline complex of the Piedmont in Virginia shows that the magnetic values increase from the granites and gneisses through the schists to the metabasalts and greenstones. Similarly gravitational values obtained over the same general area indicate an increasing gravitational effect ranging from the granites and gneisses to the hornblendites and gabbros.

It therefore appears from these data that the marked magnetic variations noted to date in the Coastal Plain are primarily due to changes in the lithology of the basement rather than to the configuration of the basement surface. In addition it has been noted that the anomaly areas occur as relatively narrow bands which have a strike more or less parallel to that of the Appalachian Mountain system.

CHROMITE IN OREGON

BY JOHN ELIOT ALLEN

Chromite deposits occur in the Klamath Mountains of southwestern Oregon and in the Blue Mountains of northeastern Oregon. They always occur in peridotite, dunite, serpentine, or associated ultrabasic rocks, thought to be Cretaceous.

The most common ore bodies are tabular lenses, though many are pod- or kidney-shaped masses, and some are narrow dikelike seams, stringers, or irregular patches. With a few important exceptions, all are small. Of 229 bodies at 141 localities in the State, only 42 gave promise of yielding over 100 tons of ore.

The attitudes of the ore bodies with respect to each other and to the surrounding rock structures and contacts strongly suggest structural control of emplacement. They usually lie within zones of hydrothermally altered rock essentially parallel to the trend of the elongated peridotite or serpentine. These zones also intersect, forming diamond-shaped strain patterns with respect to the contacts of the intrusion. The larger ore bodies seem to occur at the intersections of these zones. The longer dimensions of the ore bodies within the zones may be parallel, en echelon, or even at right angles to the trend of the zone, but in any one group they have similar orientation.

TECTONICS OF THE NORTHERN WALLOWA MOUNTAINS, OREGON

BY JOHN ELIOT ALLEN

The thick Permian (?) metavolcanic series and the Triassic marbles and slates of the northern Wallowa Mountains are intruded by the Wallowa granodiorite batholith and folded and faulted. An eastward-extending apophysis of the granodiorite, the McCully prong, divides the metamorphics into the northern or Hurricane series and the southern or Imnaha series.

The 10,000-foot section exposed in the Hurricane area is folded into a northwest-trending syncline, breached near its center by the Sawtooth granodioritic boss. At the southern end of the syncline, where it abuts against the McCully prong, the marbles are intensely folded and contorted.

The folding of the 13,000-foot series exposed in the Imnaha area consists of three well-defined anticlinal structures and their corresponding synclines. The strike of these folds trends northeasterly, paralleling the southern side of the McCully prong. They consist of asymmetrical and sometimes overturned and isoclinal folds, the latter occurring in marble.

Faulting parallel to the strike of the folding occurs in both areas, with the down-dropped sides of the faults always on the east, away from the batholith. In the Imnaha area at least four such step faults occur within 3 miles, with displacements of about 500 feet.

Tertiary faulting, with trends predominantly north-south, accompanied extrusion of basaltic lavas and resulted in the numerous north-south-trending basaltic dikes appearing throughout the region in both granitoid and metamorphic rocks. Late Tertiary folding and faulting along a northwesterly trending zone resulted in the uplift of the entire northern Wallowas as a block and the formation of the great mile-high escarpment which makes up the north front of the range.

FLINT'S FILL HYPOTHESIS OF ORIGIN OF SCABLAND

BY IRA S. ALLISON

Flint's fill hypothesis in explanation of the scabland features of eastern Washington, which based the deposition-excavation sequence upon the rise and decline of glacial Lake Lewis, has the advantage of reducing the events and conditions to terms of streams of modern size but, nevertheless, has serious shortcomings which make it unacceptable. Among the objections are: (1) erosional problems, especially the difficulty of eroding multiple channels and in removing the fill in a manner which requires decidedly abnormal, if not impossible, behavior of several simultaneous strands of current; (2) confusion of deposits of two different ages and an incorrect correlation of certain gravel deposits with the Touchet beds; (3) failure adequately to consider the rounded and sloping forms of some of the gravel terrace deposits; and (4) its insufficiency not only in the Palouse-Snake River sector but also in other scabland areas such as Wallula Gap. As it is not applicable either in the limited area or in a wider field, it must be rejected.

STRATIGRAPHIC RELATIONS OF WILLAMETTE VALLEY FILL

BY IRA S. ALLISON

Pleistocene alluvial filling in Willamette Valley is composed of three main parts: (1) high-level gravel terraces about the edges and along entering tributaries; (2) extensive gravel fans at intermediate levels about the borders; and (3) a valley floor covering, mostly of silt and fine sand, which widely overlaps the second and locally the first. The topographic and stratigraphic relations of these deposits indicate stages of alluviation separated by stages of valley deepening, extending probably from Kansan or Sherwin time to Recent. Their study involves problems of correlation, age, erosional history, relative changes of sea level, and others.

ENDOMORPHISM OF THE IDAHO BATHOLITH*

BY ALFRED L. ANDERSON

Study of many parts of the Idaho batholith shows that its rock has been considerably endomorphosed by hydrothermal solutions emanating from deeper parts of the consolidating body. The emanations, which were enriched particularly in silica but also carried variable but generally appreciable quantities of potash and minor amounts of other materials, produced many changes in the already solid rock. New or additional minerals such as biotite, orthoclase, microcline, muscovite, quartz, sphene, apatite, zircon, magnetite, garnet, allanite, epidote, zoisite, chlorite, and sericite were formed in the rock by replacing the earlier minerals. As a result, the final rock is considerably more silicic and generally more alkalic than the original. Much of the dioritic marginal rock of the batholith has been changed to a quartz-rich diorite (tonalite) and granodiorite, and the less calcic rock of the interior of the batholith from a quartz-bearing diorite and granodiorite to a somewhat calcic quartz monzonite with variations from granodiorite to granite. Dikes of associated aplite show a similar end-stage metamorphism, but most of the pegmatites have formed from somewhat later hydrothermal solutions by direct replacement of the aplitic and batholithic rock along fracture channels.

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ECONOMIC GEOLOGY OF CALIFORNIA AND SOUTHERN OREGON

BY CHAS. V. AVERILL

The Mother Lode of the Sierra Nevada, the source of most of California's gold, was formed at the close of the Jurassic in connection with the intrusion of igneous rocks ranging in composition from peridotite to granite and alaskite. The mineral province extends to the northwest from the Sierra Nevada into the Klamath Mountains.

Placer mining is increasing both on account of the $35 price and the newly developed dragline method.

Wars in Asia and Europe have stimulated interest in chromite, which occurs in substantial amounts in both California and Oregon in the serpentines that have been formed from intrusive peridotites and similar basic rocks.

Quicksilver production is being greatly increased in California and Oregon. Most of the California occurrences are in the Franciscan sedimentary series of probable Jurassic age. The formation has been intensely folded and faulted, forming traps in which the cinnabar deposits have formed. The structure of the Franciscan is so complex that many geological problems are unsolved.

The Tertiary brought important gold, silver, and tungsten deposits to southern California as well as petroleum, which is now California's chief mineral product. The largest amount of petroleum originated in the Miocene, but all Tertiary formations are productive, and a little has been found in the Cretaceous.

Other mineral products, such as copper, iron ore, platinum, limestone, clays, barite, diatomite, pumice, andalusite, talc, sulphur, salt, borates, iodine, and potash merit brief mention.

PUGET SOUND EARTHQUAKE OF NOVEMBER 12, 1939

BY JULIAN D. BARKSDALE, HOWARD A. COOMBS, AND DONALD C. BRADFORD

An earthquake awakened most of the residents of the Puget Sound region on the night of November 12, 1939 at approximately 11:47 P. S. T. (Greenwich mean time—07:45:49 Nov. 13). An isoseismal map based on data secured from 1700 questionnaires received by the University of Washington, the U. S. Weather Bureau, the U. S. Coast and Geodetic Survey, newspaper questionnaires, and letters shows the provisional epicenter to be 20 miles southwest of Olympia in the Chehalis-Oakville area of Tertiary sediments, glacial outwash, and alluvium. The Wood-Neuman (1931) modified Mercalli intensity scale was used in constructing the isoseismal map. The highest intensity was VII. The damage was limited to a few fallen chimneys, some cracked plaster and windows, a few cracked walls. Electric power lines were short circuited due to sway. The isoseismal lines make a roughly concentric pattern about the epicentral area. The pattern is greatly modified, however, where the zone of higher intensity extends up into the major river valleys in the Cascade Range. Islands of higher intensity within the Cascades can be correlated with the presence of alluvial fill. The area over which the earthquake was reported felt by persons averages 260 miles in radius, making it one of the largest on record for the Pacific Northwest.

REGIONAL APPROACH TO ECONOMIC PLANNING IN ALASKA

BY H. A. BAUER

Alaska's well-defined major geographic regions can readily be divided into subregions on the basis of physical variations.

Early development of placer mining has been responsible for a natural system of political districts and divisions delineated chiefly by divides. The four judicial divisions are practically identical with the four major drainage areas, while recording districts or precincts as a rule cover mining districts which coincide with minor drainage basins. Lack of convenient lines of transportation between regions, aided by chance development, created definite economic areas, each built upon one or more basic industries, and each having an independent service center. Sporadically distributed road systems reflect the lack of economic interdependence among these human-use regions. Seward Peninsula is a drastic illustration.

Analysis of the three basic industries—fish, minerals, and furbearers—calls for regional segregation, because species or kind of resource and methods of use change with the region or even subregion. Strong regional consciousness is a characteristic of Alaska's population; regional attitude is enhanced by divisional, *viz.* political, orientation. It is evident, therefore, that most of Alaska's economic problems are regional in character. They offer convenient approach to the planner through regional analysis. A brief outline of the problems involved in planning for a more intensive use of recreational resources illustrates the need for regional approach. The national defense program, which includes four military bases for Alaska, and the pending plans for industrial refugee settlement in the Territory also suggest a regional treatment.

LATE TERTIARY STRATIGRAPHY AND PALEONTOLOGY OF SOUTH-CENTRAL WASHINGTON AND ADJACENT OREGON

BY GEORGE F. BECK

Recent fossil plant and animal collections, especially of vertebrates, from East Selah, Buens, Snipes Mountain, Toppenish Ridge, Roosevelt, Arlington, Boardman, Taunton, and Othello, promise to revise interpretations of the late Tertiary geology of the areas cited. Whereas originally the Columbia lavas and superjacent sediments were accepted as a unit in point of time (Middle Miocene), it now appears they accumulated without essential interruption throughout much of the late Tertiary.

The post-lava Tertiary faunas now seem divisible into a western Lower Pliocene sequence and an eastern Upper Pliocene sequence without requiring a corresponding unconformity in the associated sediments. It is suggested that the sediments encroached upon the lavas progressively from west to east, with primitive hipparions at the upper basalt boundary in the Ellensburg (western) province and plesippus appearing directly above the basalts in the Ringold (eastern) province.

As early as late Miocene, palagonite phases with associated entombed raft forests suggest a general subsidence in the basalts of the Ellensburg province. In about mid-Pliocene, sedimentation seems to have begun a shift toward the east. Thus the Ellensburg beds typically intercalate among the upper Columbia lavas, while the Ringold do not. Both are conformable with the basalt.

At least local peneplanation seems to have truncated Columbia lavas, Ellensburg sediments, and Ringold beds. Upon this erosion surface a distinctive caliche zone has been developed.

STRUCTURAL FEATURES OF WASHINGTON MAGNESITE

BY W. A. G. BENNETT

The magnesite belt in Stevens County was studied by the Division of Geology during 1927 and 1928 in connection with the mapping of the Chewelah quadrangle.

Studies not yet completed with special reference to the magnesite problem itself were made during parts of the field seasons of 1934 and 1935.

The magnesite-bearing dolomite lies near the top of an apparently thick sequence of banded slates with subordinate interbedded dolomite and quartzite. These rocks are overlain in order of age by schistose conglomerate, greenstone, quartzite, and other rocks aggregating considerably more than 10,000 feet.

The slates beneath the schistose conglomerate are closely folded, overturned, and thrust faulted. The folds pitch to the northeast. Strikes commonly range from northeast to east; dips from west to north. Flow cleavage trends generally east of north and dips at various angles to the northwest. Most of the thrust faults parallel the trend of the flow cleavage.

A type of structure commonly encountered involves the west limbs and noses of northeasterly pitching anticlinal folds in juxtaposition with other west limbs.

ULTRABASIC ROCKS OF THE TWIN SISTERS MOUNTAINS, WASHINGTON

BY W. A. G. BENNETT

A study of the chromite deposits of the Twin Sisters Mountains near Mount Baker by the Division of Geology shows that the ultrabasic rocks enclosing the chromite constitute an elliptical area of northwest trend, totalling about 36 square miles. The principal rock types are interbanded, relatively unaltered dunite, enstatite dunite, and chromite-bearing dunite, all of which make up roughly 90 per cent of the rock mass. The remainder consists of a marginal serpentinized zone of peridotite and pyroxenite.

Banding is steeply inclined to vertical and lies parallel to the contact of the enclosing rocks.

Dike rocks make up a minor portion of the mass but consist predominantly of enstatite. Basalt and andesine rock occur in two places. All dikes transect the igneous banding of the peridotitic rocks.

Joints are exceedingly numerous. Two sets are distinct: (1) parallels the long axis of outcrop and has steep dips; (2) trends generally northeasterly and has moderate dips to the northwest. The former seems to have been formed independently of the igneous banding.

The heterogeneity of the ultrabasic rocks seems to be most satisfactorily explained by the hypothesis of differentiation at depth followed by injection into the position now occupied by the mass.

LOW-GRADE METAMORPHISM OF COVADA SEDIMENTS ALONG COLUMBIA RIVER

BY CHARLES D. CAMPBELL

Thousands of feet of grits belonging to the "Covada group" consist of little-deformed subangular grains in a schistose quartz-sericite-chlorite groundmass. Most of the grains truncate the schistosity, an effect possibly due to post-deformation enlargement of the grains. Argillite and slate beds consist largely of sericite, chlorite, quartz, and rutile; the formation of biotite and tourmaline in one argillite near Covada may be the result of later igneous action.

STRUCTURAL PROBLEMS OF THE EAST BORDER OF THE COLVILLE BATHOLITH

BY CHARLES D. CAMPBELL

Along several miles of its east contact with the "Covada group" a mylonitic border phase of the Colville batholith grades westward into the uncrushed granitic rock. The schistosity of the mylonitic border dips southeast at a 20- to 40-degree angle parallel

to its roof, and its linear element pitches due east. Whether this structure is a feature of intrusion or due to a later movement, the batholith appears to have suffered far greater deformation than is indicated by the low-grade metamorphism of the sediments overlying it.

SURVEY OF ALASKAN WEATHER

BY ARCHER B. CARPENTER

Popular opinion once pictured all Alaska as a frozen treeless waste, but Alaska does not warrant a blanket description. Southeastern Alaska is backed by mountains which effectively precipitate most of the moisture on the Pacific slope and leave the interior of Alaska relatively dry. The Pacific Coast and Islands region is marked by heavy rainfall, with a late fall and winter maximum. Temperatures show the marine influence of the warm Pacific in contrast to the continental extremes of temperature exhibited in the interior.

Central Alaska, or the Yukon Plateau, slopes from an elevation of nearly 5000 feet at the Canadian boundary gradually westward to the Bering Sea. The result of its continental location so far north and so well protected from the Pacific is severe cold in winter and moderately high temperatures in summer.

The climatic divisions used by Fitton are as follows:

I-a—Pacific Coast and Islands (marine)
I-b—Pacific Coast and Islands (rain shadow)
II—Bering Sea Coast and Islands (semi-ice marine)
III—Arctic Coast (ice marine)
IV—Interior (cold continental).

I-a includes all of the immediate Pacific coast with its equable temperatures and its heavy rainfall. Province I-b is modified by the Pacific influence but is behind the coastal ranges which place it in a rain shadow and permit somewhat more of a continental climate. Climate of Province II is modified by the cold Bering Sea. Province III is similarly located except that the Arctic Ocean is still colder. Province IV is distinctly continental.

SALMON FISHERIES OF ALASKA

BY F. A. DAVIDSON

There are five species of Pacific salmon: the chinook or king, coho or silver, sockeye or red, pink or humpback, and chum or dog. They are all andromous, spending part of their lives in the ocean and part in the streams where they spawn and die.

The mountainous topography, heavy precipitation, and comparatively mild climate throughout the greater part of the coastal regions of Alaska provide an ideal setting for the reproduction of the Pacific salmon. There are approximately 1000 streams in the southeastern section and 500 in the central section and along the southern shore of the Alaska Peninsula in which millions of pink and chum salmon spawn. Since the young sockeye salmon are primarily lake residents while in fresh water, the Bristol Bay region provides the largest and most ideal spawning grounds for these salmon in North America. The first salmon cannery in Alaska was established in 1878 at Klawak. By 1919 the populations of salmon, especially in the southeastern section, were at such a low level that they were in danger of complete destruction. In 1924 the White Law gave broad powers of regulation to the Commissioner of Fisheries, and under this new conservation policy the packs of all species increased, the 1936 pack being greater than any pack in the previous history of the industry.

CAMBRIAN GEOGRAPHY AND SEDIMENTATION IN THE CENTRAL CORDILLERAN REGION

BY CHARLES DEISS

Early Paleozoic geography and sedimentation in the Rocky Mountain basin were influenced by the positive element, Montania, first noted by Willis, and later described and named by Walcott the "Montana Island".

A southern Waucobian sea entered the Great Basin and transgressed northeastward over Utah while a northern sea advanced over southwestern Alberta and southeastern British Columbia. Cascadia was united with Laurentia by Montania which formed a barrier 550 miles in width across the Cordilleran geosyncline.

At the beginning of the Albertan the Cordilleran waters invaded the northern and southern parts of Montania from Canada and the Great Basin. The two seas united in northern Idaho and northeastern Washington forming the Idaho Straight, and in northern Montana in the Eastern Rocky Mountain Basin. In Middle Cambrian, Montania was a low island whose apex lay in the region of Glacier National Park.

The western part of Montania was elevated before the opening of the Croixan when a sea lay to the east in central-west n Montana and extended northeast across southern Alberta into the deeper part of the Cordilleran geosyncline in southeastern British Columbia.

Montania was elevated slightly before the Ordovician and remained above water until Middle or Late Devonian. Consequently, Middle or Upper Devonian limestone rests nearly conformably upon eroded Middle Cambrian dolomite in northwestern Montana.

The climate was warm, humid, and uniform throughout the region during most of the Cambrian, but local aridity and possibly lower temperatures may have prevailed during the Croixan.

FUNDAMENTAL BASES OF NORTHWEST GEOGRAPHY

BY O. W. FREEMAN

The development of industries, culture, and landscapes in the Northwest depends on a combination of natural and human factors. Among the fundamental natural factors are: (1) geology that affects location of minerals and character of relief features; (2) physical features that affect climate, drainage, water power, and land utilization; (3) climate, determined by such factors as latitude, relief features, exposure to winds and ocean, and the paths followed by cyclones; (4) location that affects commercial relations with the rest of the United States and foreign countries; and (5) type and cultural development of original settlers and later immigrants.

GLACIAL DRAINAGE CHANGES NORTH OF THE COLUMBIA PLATEAU

BY O. W. FREEMAN

The Okanogan Highlands and other ranges of northeastern Washington were covered by glacial ice that moved southward from the intermontane plateau of Canada. The southward extension of the ice sheet has been mapped by Bretz and Flint, who have also given their interpretations for the origin of the scablands that were eroded by glacial meltwaters. North of the area they describe are dozens of glacial drainage channels and other features such as marginal lakes and associated spillways that were developed during the melting and wasting of the ice sheet. Since the glaciers were thickest in the major valleys, the drainage channels generally form a braided sort of

pattern on both sides of such north-south-trending trenches. The character of deposits made by the meltwater during the glacial period is briefly mentioned. A map showing the location of the glacial drainage channels of Washington accompanies the paper.

ELLIPSOIDAL STRUCTURE AS THE GIGANTIC DISPERSE PHASE OF AN EMULSION

BY RICHARD E. FULLER

The ellipsoidal structure of basaltic lavas is considered by the writer to have been formed as the gigantic disperse phase of an emulsion in which the disperse medium was essentially aqueous. As in all emulsions, the dispersal of the fluid with the higher surface tension may have been attained either by the agitation of the two phases or by its entry as detached units. Aside from the magmatic force, the agitation is attributed principally to the explosive action of generated steam, but its effect would have varied according to the pressure. In submarine extrusions and where deepseated intrusions encountered groundwater, the superheated steam would have retarded the chilling of the basalt and would have contributed to the mobility of the gigantic emulsion, thus permitting the wide development of the compacted structure in massive formations.

In central Washington many flows show the effect of basal chilling which differs widely in type depending on the mass and fluidity of the lava at the moment of contact and on the moisture which varied from mud flats to extensive lakes. The latter retarded the advance of the lava which either poured into them and granulated like slag, or with sufficient viscosity tumbled in as great droplets and accumulated to the depth of the water to permit the gradual advance of the flow on a relatively even surface. Locally these highly chilled uncompacted pillows had sufficient viscosity to retain their droplike shape, but in analogy to emulsions some solidified in the process of coalescing, while others show the effect of disruption by either rising steam or gravity. The persistence of these basal horizons for a mile or more with a thickness even in excess of 100 feet refutes a subaerial origin based on the fortuitous development of surface features of successive flows.

BROWNS POINT FORMATION, OLYMPIC PENINSULA, WASHINGTON

BY SHELDON L. GLOVER

Investigations under way for the State Division of Geology on the west coast of the Olympic Peninsula have shown the occurrence of a distinct marine sedimentary series in strata designated by earlier workers as a part of the Hoh formation. This is here termed the Browns Point formation. Comparative studies indicate it is younger than the Hoh formation, older than the immediately overlying early Pleistocene Taholah formation or late Pleistocene Queets beds, and also older than the Pliocene Quinault formation.

The type section comprises about 5000 feet of moderately cemented buff to gray arkosic sandstones and thin-bedded dark-gray mudstones which occur along 3 miles of coast from the NE¼ sec. 33 to the SW. cor. sec. 16, T. 25 N., R. 13 W. Similar rocks, not before described, form Destruction Island and also 1500 feet of exposures at Grenville Bay.

At the type locality the strata are on the south flank of a northeasterly trending anticline. Minor flexures occur, some beds are vertical or overturned, but much of the series has a moderate southeast dip. Destruction Island is the compressed axial portion of a vertically plunging syncline; the axial plane extends west between the island and northerly reefs.

Miocene (Astoria?) age is indicated by a scant fossil assemblage and on lithologic and structural evidence. The series is considered a near-shore phase of sedimentation with prominent development farther west, though extensions under the Pleistocene cover to the southeast are probable.

NEW DATA ON THE DISTRIBUTION OF IGNEOUS ROCK IN THE OLYMPIC PENINSULA, WASHINGTON

BY SHELDON L. GLOVER

Investigations begun on the Olympic Peninsula in 1923 and culminating in extensive work during 1934, 1938, and 1939 for the State Division of Geology show igneous rock there to be more widespread than was indicated by early investigators. Virtually all such rock has been described as of the Metchosin and Crescent formations and as being confined to a U-shaped belt surrounding the Olympic Mountains on the north, east, and south. It was unknown in the central area or west of it along the coast. This paper calls attention to rocks similar to these volcanics outside the igneous belt as mapped, on the Elwha, Dungeness, Quilcene, Dosewallips, Skokomish, Quinault, and lower Humptulips rivers. Exposures are as much as 14 miles from the previously mapped contacts of volcanics and older or younger sediments and indicate that the mapped area of Eocene volcanics should be expanded.

Other igneous rocks, previously undescribed, occur along the west coast in formations predominantly sedimentary. A basalt flow in the Pliocene Montesano formation is exposed at Hoquiam. Andesitic intrusives and extrusives are commonly associated with sediments of the pre-Miocene Hoh formation, occurring as occasional plug- or sill-like bodies, dikes, and abundant pyroclastic phases that include agglomerate, andesite breccia, and tuff. Characteristic exposures occur at Grenville Bay; Hogs Back, Little Hogs Back, and vicinity; Abbey Island; and near Goodman Creek. These volcanics appear to be closely associated with vents and include rock types common to the central Olympics as well as some types otherwise unknown in this region.

CRITERIA TO AID IN DISTINGUISHING ORTHOMAGMATIC FROM METASOMATIC ROCKS

BY G. E. GOODSPEED

In the Pacific northwest are many occurrences of volcanic rocks derived from the extrusion of hot liquid silicate melts or orthomagmas and intrusive rocks due to the crystallization of such magmas. They exhibit in a most characteristic fashion the usual structures engendered by the cooling and crystallization of a hot liquid silicate melt. Under the microscope these rocks show typical igneous microtextures and structures; their pyrogenic minerals are usually clear and have well-defined boundaries one with another. Some contain rectilinear inclusions of the groundmass parallel to crystallographic planes of the mineral. They are also in physico-chemical harmony with the other pyrogenic constituents of the rock. Effects of contamination are such as might be expected in hot liquid magma, and some show definite evidence as to the temperature at the time of consolidation.

This region also has many occurrences of rocks which by the casual study of a few specimens or sections would be considered of igneous origin. However, the field evidence of transitional facies derived from excellent exposures clearly indicates that they have been formed by metasomatic processes rather than by the crystallization of lavas and magmas. Gradational contacts of igneous-appearing rocks into rocks of

sedimentary origin, undisturbed relics, and the structural position of these rocks all point most strongly to metasomatic rather than magmatic origin. Likewise microtextures and structures exhibit the many significant criteria of crystalloblastic growth rather than those characteristic of a crystallized melt. Contemporaneous association of low temperature minerals and even such materials as coal with the igneous-appearing aggregates suggests comparatively low temperatures of metasomatic processes rather than the elevated temperatures of orthomagmas.

BONNEVILLE-GRAND COULEE POWER AND ALASKAN MINERALS

BY EDWIN T. HODGE

The hydroelectric sites of Grand Coulee and Bonneville are being interconnected with each other and the Seattle-Portland coastal areas. Their power will soon be available for electrochemical and metallurgical industries. Alaska can be the main source or serve as a supplemental source for mineral raw materials. For a steel industry the magnetite-copper deposits of southeastern Alaska and of Iliamna Bay can serve as supplemental sources. Alaskan coal is no better than coals available in Washington. The Northwestern States are deficient in pure limestone located economically close to industrial sites, and those of Dall Island, Alaska, can be laid down in Portland at a lower cost.

The lead and zinc deposits of Alaska may benefit by the establishing of treatment plants on tidal waters. Electro-alloy industries now dependent upon foreign sources justify exploration of the tungsten possibilities of Alaska. Chromite is not known to occur in Oregon and Washington in bodies large enough to permit low cost production, but at Port Chatham and Red Mountain, Kenai Peninsula, there is a deposit of 240,000 tons.

The dependence of the United States upon foreign antimony might be eliminated by plants to treat antimonical ores that are widespread in Alaska, for example near Fairbanks.

GLACIAL HISTORY OF SOUTHEASTERN WASHINGTON

BY EDWIN T. HODGE

The basin of southeastern Washington was drained by westward- and northward-flowing streams. The former were dammed by Pleistocene volcanics, and the latter by the Continental ice sheet. Ponded waters filled the valleys of the Columbia Mountain system but did not submerge the higher ridges; they spilled over cols in the Sanderson-Cheney divide, deepened them, and so directed the course of ice lobes from the advancing ice-front. The glaciated cols produced the coulees, such as Grand and Moses. The ice reached as far south as Ephrata and Ritzville and over the area plucked the highly fractured basalt to make great gravel deposits and left holes filled with ice which are now sheer-walled undrained basins. Loess and gravel were spread over the greater part of the area, burying ridges and forming a lake-bed surface with an initial south-sloping surface. The lake was drained by an overspill at Wallala Gateway. As the glaciers melted, streams flowed southward over this surface. Some, and particularly the Columbia, were superposed over ridges, such as Horse Heaven, Rattlesnake, Frenchman, and Waterville-Adrian. These streams were often choked and dammed by ice-floes and so were forced out of their channels. Repeated damming of the diversion channels produced a complex anastomosing complex of channels incised in the basalt. Erratics rafted by ice blocks were stranded over the area and in addition along the Columbia and Willamette valleys in Oregon. Similar events followed a second and third ice advance.

MINERAL RESOURCES OF THE NORTHWEST

BY EDWIN T. HODGE

The development of great hydroelectric plants such as Grand Coulee and Bonneville warrants consideration of possible hydroelectric industries. Studies made by the writer yield the following results:

Many small iron ore deposits exist, but an economic smelting unit must depend upon large deposits of magnetite located on the southern coasts. Limestone can be most economically obtained from Dall Island, Alaska. Refractory and ceramic clays occur in Lane County, Oregon; Cowlitz County, Washington; and Latah County, Idaho. Large deposits of silica occur near Spokane. Magnesite for refractories and metal occur in a large deposit near Chewelah, Washington. No manganese deposits of sufficient size or quality occur unless those at the northern end of the Olympic Peninsula can be proven economical. Numerous small chromite deposits occur in Oregon and Washington. There are only prospective occurrences of cobalt, tin, tungsten, molybdenite, and nickel. A lead and zinc treatment plant for areas not well served has no present assured tonnage. Saline deposits are probably widespread. Great phosphate deposits occur in southeastern Idaho which might be treated by a plant on the Snake or upper Columbia rivers.

STRUCTURE AND PETROGRAPHY OF THE OREGON CASCADES

BY EDWIN T. HODGE

The Oregon-Washington Cascade Mountains lie between and overlap onto older highlands of northern Washington and southern Oregon. Below, eastern continental volcanics and western marine sediments of early Eocene age met, were eroded maturely, and overlain by lower Miocene pyroclastics (Warrendale), middle Miocene Coriba lavas; both were gently folded in late Miocene, eroded youthfully in early Pliocene, yielding the Coriba surface which extended from the Coast to Idaho.

Upon Coriba surface the Cascade Range was built as a pile of volcanics along a north-south zone of close folding and faulting and as a belt 50 miles wide on either side. Volcanism, yielding 90 per cent lavas and 10 per cent pyroclastics, continues to the present time. Troutdale formation lies under the Dalles Beds, is deeply weathered, and related to an older series of Pliocene andesites. Many pyroclastics formed torrential Dalles formation of late Pliocene, lying on Rattlesnake of middle Pliocene.

The main bulk of the Cascade pile was accumulated in Pleistocene time, and the Columbia River canyon was cut in middle Pleistocene.

The John Day formation is mostly andesitic ash and tuff; the Clarno contains much rhyolite, some andesite, and basalt; the Coriba and Mascall is an olivine-free, andesine basalt (hawaaite); the Dalles lavas are olivine basalt; the Cascan formation is a pigeonite-labradorite andesite with local phases varying from traehyte, dacite, to basalt. The later lavas are largely olivine basalts and obsidians.

STRATEGIC POSITION OF CALIFORNIA IN GEOLOGY AND MINERAL INDUSTRY

BY OLAF P. JENKINS

The phenomenal growth of industry in California has been dependent upon the unique geographic position of the State, its rich endowment in mineral wealth, its variability in physiographic provinces, and its isolation—all features which have evolved from a geologic history most varied and eventful. Though 1200 miles of

boundaries separate it from three adjoining States and one foreign country, few of its well-described geologic formations (over 600) extend beyond these boundaries, and only a few of its 11 major physiographic and mineral provinces even extend into the territory of adjoining neighbors.

Salient events in California's geologic record are closely connected with the origin of its mineral deposits, from which 70 different commercial products are obtained—each of the 58 counties of the State contributing something. In a total of 9¼ billion dollars' worth of these mineral products, nearly 60 per cent are mineral fuels (oil and gas); over 25 per cent metals; 10 per cent structural products; over 3 per cent salines; and nearly 1½ per cent the so-called industrial minerals. As a leading producer of four of the nation's strategic minerals (quicksilver, chromite, tungsten, and iodine) and with reserves also of manganese, antimony, and tin, California should play an important role in time of war. It is the world's chief source of borates, and its first rank in natural soda, diatomite, pumice, and volcanic ash, and second rank in cement place California in a position of eminent importance. Except in the petroleum industry, however, geology has not progressed as far into economic fields as in purely scientific problems, and there is much pioneer work to be done, especially in nonmetallic economic geology—for example, in the $12,000,000 clay industry.

TUNGSTEN-BEARING MANGANESE DEPOSIT AT GOLCONDA, NEVADA

BY PAUL F. KERR

The tungsten deposit is situated just above the former high water level of Quaternary Lake Lahontan a short distance east of Golconda, Nevada. Manganiferous and ocherous deposits containing tungsten are overlain by calcareous tufa. The ore minerals are colloidal in nature, tungstic acid having been adsorbed in psilomelane and limonite while both were gels. The tufa is considered chiefly of hot spring origin rather than the result of precipitation from Lake Lahontan. The tungsten ores lie in blanketlike form on an erosion surface which truncates tilted sediments. Underlying the blanket deposits are veins of similar mineralization which are thought to have provided the source of the overlying ores. The blanket deposits are sufficiently large and contain enough tungsten to justify economic development.

A jarosite-bearing vein containing small amounts of tungsten occurs at a slightly higher elevation where the hot springs deposition has been removed by erosion. The vein cuts steeply inclined limestone which has been considerably altered to chert and highly silicified with the production of quartzitic masses. This vein is thought to be significant of a lower level of mineralization than the veins immediately below the blanket deposits.

It is believed mineralization started with chertification and silicification but ultimately resulted in precipitation of tungsten, iron, and manganese followed by tufa. The source of the tungsten is not exposed, but occurrences of other tungsten deposits in the vicinity suggest the possibility of underlying scheelite or wolframite-bearing veins. (Geological Society project.)

OREGON'S MINERAL INDUSTRIES AND MINERAL RESOURCES

BY F. W. LIBBEY

Oregon's active mineral industries in the order of importance are in the following categories: in the metals, gold (silver), quicksilver, platinum (osmiridium), copper, and lead; in the nonmetals, sand, gravel, and crushed rock; limestone, clay, agates,

semi-precious stones, diatomite, coal, monumental stone, silica, pumice, mineral waters. In addition, the State has known potentially valuable deposits of chromite, iron ore, manganese, nickel, antimony, zinc, salines, marble, building stone, and peat.

Of the metals, gold production is the largest, amounting to $3,188,500 in 1939—an 11% increase over 1938. Lode mines accounted for about one-third of the gold production. Placer production is mainly from dredging. In May 1940 there were 26 operations classed as dredges; 5 were standard bucket line; 15 were dragline; and 6 used power shovel excavators.

Quicksilver is second in value of metallic production, increasing from $348,000 in 1938 to $477,293 in 1939. Oregon ranks second among the States in value of quicksilver production; output is increasing rapidly.

The value of Oregon's nonmetallic mineral production in 1939 is estimated at $5,500,000. The largest part of this value is from sand, gravel, and crushed rock used in construction. Limestone, chiefly processed to make Portland cement, ranks second. The State has large reserves of good grade stone.

As the population of Oregon and the Northwest increases, the value of Oregon's nonmetallic mineral production will become increasingly important in the State's economy.

ORIGIN OF CLASTIC DIKES IN THE LEWISTON BASIN, WASHINGTON AND IDAHO

BY RALPH L. LUPHER

Numerous clastic dikes penetrating Pleistocene sediments have long been known in southeastern Washington. They occur also in the Lewiston region in gravels, sands, and silts related to glacial stages, and even in the basalt lavas beneath. The dikes are composed of clay, silt, sand, gravel, and basalt rubble. Dikes and enclosing deposit are rarely alike in grain size. Many dikes are of a multiple character, showing repeated opening and filling of small fissures. The dikes are almost invariably bounded by thin laminated clay layers representing the accumulation from muddy water.

Many lines of evidence show that most fissures were filled from above. More than one process of filling is indicated, but most commonly running water dropped sediment into a water-filled fissure. The sediment accumulated upon the "foot-wall" of the fissure and, reaching the top of the upbuilding dike, it commonly assumed the angle of repose oblique to the fissure walls and produced stratification which reflected the fluctuations of current and materials in the running water above. Some dikes were filled with infalling material without the aid of running water.

Strong evidence shows that the fissures are not the result of earthquakes. On the contrary, a very gentle opening process is required. Some fissures, particularly those that reach into the bedrock, are related to slumping, but there is some evidence that settling resulting from the melting of buried ice may have been the most common origin.

PLEISTOCENE HISTORY OF THE LEWISTON BASIN OF WASHINGTON AND IDAHO

BY RALPH L. LUPHER

The Lewiston-Clarkston region reveals a sequence of Pleistocene events which has some bearing on the development of scablands and related features in central and southeastern Washington.

Warping and faulting of the Columbia River basalts and overlying "Ringold formation" produced the Lewiston Basin and adjacent structures. Major streams, controlled largely by the initial stage of deformation, cut canyons, commonly 2000 feet deep, in the elevated tracts around the basin.

The streams had cut nearly to their present depths when a fill of gravel, sand, and silt accumulated to a maximum depth of more than 400 feet in the canyons tributary to the basin. For example, a former course of the Snake River southwest of Clarkston is filled with iron-stained, partly consolidated foreign gravels to an altitude of 1150 feet, or more than 450 feet above the present river bed. Above the fill, canyons were widened by erosion.

The fill was later dissected as the streams cut down nearly to their present depths, and the Snake River established a new course north from Asotin, entering the Clearwater channel at Clarkston. Dissection of the older fill was followed by a stage of ponding. Considerable deposits of gravel and sand of this stage are present up to an altitude of more than 1000 feet, and a thin layer of silt and ice-rafted erratics extends over the hillsides to an altitude of 1325 feet. A final stage of dissection brought the streams to their present courses.

GLACIAL GEOLOGY OF SNOQUALMIE-CEDAR AREA

BY J. HOOVER MACKIN

The Cedar River and the Middle and South Forks of the Snoqualmie rise in axial highlands of the Cascades and enter the Puget Lowland approximately 100 miles south of the Canadian boundary. The first event of the Vashon (Wisconsin) glacial stage in the Snoqualmie-Cedar area appears to have been a moderate extension of the Cedar and Snoqualmie valley glaciers; whether these local Cascade glaciers reached to or beyond the mountain front is not known. In any case, the Cascade valley glaciers had retreated at least 3 miles before the Puget glacier lobe, of Canadian origin, attained its maximum extent, and the local glaciers did not contribute to the mass of the Puget glacier at any time during the Vashon stage. The east marginal part of the Puget glacier moved southeastward, toward the Cascade mountain front, and built large morainal embankments in the lower mountain valleys of the Cedar and Snoqualmie rivers. The entering ice impounded long "Glen Roy" lakes in these mountain valleys, which had been occupied, shortly before, by local glaciers. During the period of downmelting from its terminal moraine, and during the building of a recessional moraine, the Puget glacier appears to have been active. (Geological Society project.)

RIPPLE MARKS (?) IN GLACIAL LAKE MISSOULA, MONTANA

BY J. T. PARDEE

Numerous gravel ridges in Camas Prairie, a small intermontane basin in northwestern Montana, show the form, structure, and arrangement of ripple marks but are of extraordinary size. They range in height from a few feet to as much as 50 feet and are spaced 200 to 500 feet apart. It is suggested that ripple marks of such dimensions might be produced if a great flood of water moved southward across Camas Prairie. Features indicating that such a flow may have entered and left the basin are the presence of several wind gaps in the northern rim, to serve as inlets, and a pass at the south.

Camas Prairie is not far outside the definitely known area of Pleistocene Cordilleran glaciation, and a temporary influx of water across its northern rim might have been caused by an ice dam in the outlet of the neighboring Little Bitterroot valley. Camas Prairie is also within the area flooded by an arm of glacial Lake Missoula, and the topographic relations of this basin are such that a rapid draining of the lake might have caused, for a brief time, a huge current to flow across it. Certain gravel deposits in side gulches along narrows in Clark Fork valley near-by may be explained as bars formed by large rapid outflowing currents.

GROUND-WATER PROBLEMS IN THE PACIFIC NORTHWEST *

BY ARTHUR M. PIPER

The ultimate social, economic, and industrial evolution of the Pacific Northwest probably will be determined to a considerable degree by its water supplies. Among the sources of water, those derived from beneath the land surface—that is, from bodies of ground water—are by no means inconsequential.

With respect to ground water, the region can be divided into at least four provinces whose extent is determined by geologic, geomorphic, and climatic factors. These four are: the Northern Coast Ranges province, the Puget-Willamette Trough province, the Columbia Plateau lava province, and the Northern Rocky Mountain province.

The mode of ground-water occurrence and the major ground-water problems of each province are described; the status of systematic ground-water surveys in the region is also reviewed.

INFLUENCE OF STRUCTURE ON ORE DEPOSITS IN THE COEUR D'ALENE DISTRICT

BY JOHN B. PLATTS

All the phenomena of structure, igneous intrusion, and ore depositions in the Coeur d'Alene district may be referred to the action of a recurring lateral thrust or pressure from the northwest toward the southeast that was general over a large area, including much of the Pacific Northwest.

The lateral thrust folded the competent Belt sediments into a series of northeast-striking folds with their steep sides toward the southeast. Igneous intrusion followed the planes of weakness in axial shears of anticlines. Discussion centers around one of these folds called the Coeur d'Alene anticline.

Periods of heavy thrust alternated with quiet periods. After stocks of quartz monzonite had been intruded into the folds, further movement developed a regional shear and a system of major tear faults.

High temperatures accompanied the monzonite intrusion, and each succeeding thrust caused a temporary rise in temperature during the long cooling period. Old fractures were reopened by each recurring thrust, mineralizing solutions found their way into regions of tension in the fracture system, and a series of ores corresponding to falling temperatures were deposited.

The principal mineralized areas in the Coeur d'Alene district are described in a general way. Conditions found there support the above generalizations. The practical application of structural data to the search for ore is discussed briefly.

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UTILIZATION OF PUBLIC LANDS IN ALASKA

BY JOHN R. RIGGLEMAN

The natural resources of Alaska—namely, her fisheries, wild life, minerals, and forests—embody a present and potential wealth of great national importance. Her fisheries and fur trapping have produced over a billion dollars' worth of products, and her mines three-quarters of a billion.

Alaska is roughly one-fifth the size of the United States. Approximately 85 per cent of the land is vacant, unappropriated, and unreserved and is under the jurisdiction of the General Land Office of the Department of the Interior. Less than one-tenth of 1 per cent of the land has been patented to private ownership. One of the greatest needs in administering Alaskan lands is adequate classification, based upon detailed information as to their agricultural, mineral, and other possibilities. For many years it has been the policy not to sell the fee to forest, coal, and oil lands. Lands for homesteads, industrial sites, and certain other forms of occupancy, and for mining purposes exclusive of coal or oil, may, however, be patented under appropriate laws.

Need for orderly and prudent development of the Territory long has been recognized. Alaska can serve solely as a source of raw materials, but it is capable of developing its own reasonably independent economic life. In Alaska, however, development of agriculture will follow rather than precede industrial development. Perhaps the development of renewable and nonwasting resources in the form of fish, timber, fur, game, water power, and scenery will assume the role usually played by agriculture in providing a foundation for a stable and permanent economy.

ALASKA'S AGRICULTURAL FUTURE

BY W. A. ROCKIE

Opinions differ widely regarding (1) possibilities of Alaska agriculture, (2) amount of suitable land, (3) location of these lands, and (4) success of present agriculture, but a study of the physical factors points to ultimately successful agriculture. Although many natural and economic factors are important, the individual seems to be a dominating factor for or against success.

Present estimates indicate that $\frac{1}{6}$ of Alaska's 384,000,000 acres is agricultural, $\frac{1}{14}$ grazing land, $\frac{1}{500}$ now in farms, and only about $\frac{1}{50,000}$ of the Territory yet uncultivated. The best lands are around Cook Inlet and around Fairbanks. Occasional truck, dairy, fur, and diversified farms are successful, but there are many that have failed. The government colony at Palmer is the present agricultural center of the Territory, with half of all cultivated land in Alaska within 10 miles. The other cultivated lands are scattered in hundreds of localities. A wide variety of crops and of livestock is grown.

The first detailed land-use studies in Alaska are now in progress in the Matanuska Valley. Aerial photographs show large areas of both good and waste land including an almost inconceivable variety of physiographic forms.

Wind erosion presents a real threat to cleared lands around Cook Inlet, and soil washing and sinking of land are serious land problems in the Fairbanks region.

Agriculture has shown relatively little development to date, but, judging by successful farms in many localities, no fundamental reasons exist why agriculture in Alaska should not become a successful major industry. It can become another Scandinavia.

EPOCHS OF VOLCANISM IN THE SALT LAKE CITY REGION

BY HYRUM SCHNEIDER

The geologists of the "United States Geological Exploration of The Fortieth Parallel" mapped seven areas of extrusives east and west of the Central Wasatch Mountains as trachytes and apparently considered them all essentially alike and all younger than the Eocene sedimentary rocks of the region.

A field and microscopic study of the volcanic rocks mapped as trachytes in City Creek Canyon, just outside Salt Lake City, and of the extrusives along Silver Creek about 20 miles east of Salt Lake City, shows the rocks to be Paleocene andesite breccias instead of post-Eocene trachytes.

An oil well drilled about 2 miles north of the Salt Lake Airport passed through a 2½-foot bed of pumiceous tuff at a depth of 1308 feet. Elmer Berry determined the fossils of the associated beds as late Pliocene.

At 60th West and Magna road near the Whittier School, there is exposed in the bottom of an irrigation ditch a volcanic breccia much like the breccia in City Creek Canyon but more basic. The rocks at 60th West are a basalt breccia with an interbedded tuff. The age of the basalt breccia cannot be definitely determined, but since it outcrops 1400 feet above the tuff bed in the oil well it is probably post-Pliocene.

Within a radius of 9 miles from Salt Lake City there are three different types of volcanic rocks produced from different volcanoes at different times.

GEOLOGY OF THE SHASTA COPPER BELT

BY G. F. SEAGER

The Shasta County copper belt lies in the extreme southern part of the Klamath Mountains. Except for important gossan operations for gold, the district is idle today after 35 years of mining during which it yielded much copper, zinc, gold, silver, and sulphur.

Two sedimentary formations occur in the western part of the copper belt, the Kennett (middle Devonian) and the Bragdon (Mississippian). Also, remnants exist of a thick and extensive pre-middle Devonian andesitic complex, known as the Copley meta-andesite. A large, irregular intrusion of soda alaskite porphyry of late Jurassic age introduced the copper deposits. The intrusive is intensely altered hydrothermally and locally cataclastically deformed.

The copper deposits are of two distinct mineralogical and morphological types and are classed as (1) massive pyritic deposits and (2) chalcopyrite lodes. The former are massive replacement bodies of pyrite, with subordinate chalcopyrite and sphalerite, whereas the latter are veinlike partial replacements of alaskite porphyry by chalcopyrite, yielding a concentrating ore.

Convincing evidence exists that the deposits were formed by replacement of soda alaskite porphyry essentially similar to the wall rocks. The occurrence of the deposits along a pronounced shear zone in the intrusive indicates that replacement was governed chiefly by the physical condition of the rock and that the sulphide deposits were localized at places of maximum comminution. The deposits are genetically related to the soda alaskite porphyry and likewise are dated as late Jurassic.

Thick gossans have formed on some of the sulphide bodies, and locally important supergene sulphide enrichment has occurred. Within the last decade, the gossans

have proved themselves an important source of gold. The manner of occurrence of the gold in the gossan is especially noteworthy, since some of the gold seems to be water-soluble. From the gold distribution, and also from experimental evidence, there is a suggestion of minor supergene enrichment.

LARGER PHYSICAL FEATURES OF ALASKA

BY PHILIP S. SMITH

The great extent of Alaska, due not only to its actual area of nearly 600,000 square miles but also to its irregular sprawling shape, accounts for the wide diversity of geographic and related features that exist in various parts of the Territory. These differences are expressed in the topography, climate, population, and resources and their utilization, all of which distinguish different parts of Alaska. Thus, there are lofty mountains, lowlands of slight relief, and rolling hills and plateaus of intermediate elevation. There is the rather equable, moderately cool, very wet climate of the southern coastal area, the moderately dry, strong temperature range of the interior country, and the very dry polar climate of the northern coastal region. On all of these are superposed variations due to relative elevation above sea level and to proximity to or remoteness from the ameliorating effects of the ocean. Four principal divisions of the country are described on the basis of their dominating topographic characters. These are the southern mountain highland, the plateaus of the interior, the northern mountains, and the northern plateaus and plains that terminate at the Arctic Ocean. The position, extent, and principal geographic features of each of these subdivisions are described briefly.

MINERAL RESOURCES OF ALASKA

BY PHILIP S. SMITH

Many different minerals enter into the mineral industry of Alaska in the period since 1880. Minerals to the value of more than $800,000,000 have been recovered from the mines of the Territory. So far, gold and copper account for much the larger part of this value; together they furnish 95 per cent of that total, gold accounting for about 67 per cent. About two-thirds of the gold has come from placers in widely separated parts of the Territory; those most productive are in the Yukon and Seward Peninsula regions. Gold from lodes has been recovered at many camps, but those in southeastern Alaska have been the largest and most productive. Most of the copper has come from unique rich deposits near Kennecott, in the Copper River region. These mines discontinued operations in 1938, and there is little likelihood that in the near future there will be significant production of copper from Alaska. Among the notable newer developments is that of the platinum-bearing placers in the Goodnews district, near the mouth of the Kuskokwim River. The production from this area, as well as from a small placer gold camp in Seward Peninsula and a lode deposit in southeastern Alaska, places Alaska among the four or five largest producers of these metals in the world. Coal sufficient to supply the greater part of the domestic needs is being mined each year. Although recovered mainly as by-products from ores in which other metals are the principal valuable constituents sought, lead and silver each year add to the output of minerals from the Territory. No petroleum is now produced from Alaska deposits. Other metals and nonmetallic products that have at times entered into the mineral production of Alaska are antimony, chromium, tin, mercury, arsenic, bismuth, molybdenum, tungsten, marble, limestone, barite, gypsum, graphite, and sulphur.

STRATIGRAPHY OF ALASKA

BY PHILIP S. SMITH

The paper summarizes the general stratigraphic succession of Alaska formations as now known. Rocks representative of all geologic periods, as well as of most of the epochs, have been identified in various parts of the Territory, and this paper describes the dominant lithologic and structural relations of each of the larger units. The record, as now disclosed, embraces many episodes of sedimentation under marine, estuarine, or terrigenous conditions and igneous activity, whereby deep-seated or surficial volcanic rocks were formed, some of whose representatives range in composition from ultrabasic to highly acidic. Profound diastrophism is recognized at a number of intervals in the pre-Cambrian and later systems. The structures produced by these deformations prior to those in the latter part of the Mesozoic era are no longer recognizable through the definite land forms they make but must now be inferred from the effect they had on the then-existing rocks or on the physical character of the deposits resulting from those movements. At the close of the Lower Cretaceous epoch great orogenic movements seemed to have blocked out roughly many of the larger present-day lineaments of Alaska. However, stupendous uplift and mountain building occurred well into the Tertiary, and the numerous volcanoes that are still active bear witness that some of the processes within the earth's crust are even now operative.

OREGON SHORE LINE

BY WARREN D. SMITH

This paper deals with some of the more essential features of the Oregon coast and particularly some of the recent changes that have taken place. The Oregon shore line is composite. In the first part of the paper there is a short discussion of the classification under which different parts of the shore line are considered.

This is followed by a discussion of eight or ten of the most striking geological and scenic features of the coast from the California line to the Columbia River. The Oregon coast may be divided generally into a southern portion from the Coquille River south where the shore line has been developed in older and harder rocks, and a northern portion, developed in younger Tertiary formations, which are much softer.

The paper concludes with a few of the more important changes in human geography along this coast line within the last 10 years which are directly or indirectly referable to the geological features.

REGIONAL CONTROL OF OREGON QUICKSILVER DEPOSITS

BY LLOYD W. STAPLES

All the known quicksilver prospects and mines for Oregon have been carefully plotted on a map of the same scale as that recently published by the California Division of Mines. Study and comparison of the Oregon and California regions of quicksilver mineralization support the following conclusions: (1) Because of the widespread distribution and lack of concentration of deposits in Oregon, structural trends are not so evident as in California. (2) The western edge of the Cascades produces an alignment of deposits similar to that controlled by the San Andreas fault in California, but most of the Oregon deposits are of lower grade. (3) Between the Bonanza region and the Clackamas no quicksilver deposits are known. Future dis-

coveries in this area are not unlikely. (4) The alignment of deposits in other parts of the State is controlled by local structural features. An example of this is the north-south alignment in the Steens Mountain region.

DISTRIBUTION OF HISTORIC EARTHQUAKES IN THE PACIFIC NORTHWEST

BY RAY C. TREASHER

Plotted locations of recorded earthquakes in the Pacific Northwest are concentrated in the Puget Sound area particularly in the Olympic Mountains, at Seattle, Everett, Sultan, and Bellingham. Other localities, in eastern Washington, are at Chelan, Ellensburg, and Walla Walla. The Walla Walla recordings are due to the State Line earthquake with an epicenter near Milton and Freewater, Oregon. Oregon is notably free of earthquakes. The principal exception is the State Line earthquake. The conclusion is that the Pacific Northwest is relatively stable except for the Puget Sound area.

GEOLOGY OF THE PORTLAND (OREGON) AREA

BY RAY C. TREASHER

The areal geology of the Oregon portion of the Portland and Troutdale quadrangles and the north half of the Oregon City and Boring quadrangles is being mapped for the Oregon State Department of Geology and Mineral Industries. The oldest formation is basalt that probably correlates with the Columbia River Basalt. It is overlain, unconformably, by the Troutdale formation, a torrentially bedded series of sandstones, lava grit, and pebble conglomerates and is here considered as of Pliocene age. Erosion produced a mature surface on the Troutdale formation with a relief of about 400 feet, onto which poured a series of volcanic flows of local origin. These flows, the Rocky Butte Volcanics, capped many of the hills and filled some of the valleys prior to or during early stages of continental glaciation. Glacial melt waters from Mount Hood poured down the Sandy and Bull Run rivers, tore out portions of the Rocky Butte Volcanics, deposited outwash on the Boring Surface, and dumped eroded Rocky Butte Volcanics and surplus outwash in the Columbia River valley. This debris forms the Portland Gravels. At the same time, waters in the Clackamas Valley deposited eroded Troutdale formation and outwash to form the Clackamas Gravels. From some unknown source, a thick deposit of fine-grained silt with loessial characteristics was deposited over the Portland area to a maximum thickness of 200 feet.

Weathering is deep, and some of the surface gravels, lava rubble, and lava-in-place are altered to clayey materials. This type of weathering is not uncommon in the area west of the Cascade Range and is herein designated as the Mayger type of weathering, from the type locality at the Fransen clay pit near Mayger, Oregon.

RELATION OF PLATEAU BASALTS OF EASTERN WASHINGTON TO CERTAIN ANDESITIC ROCKS OF THE CASCADE MOUNTAINS*

BY WALTER C. WARREN

The Yakima basalt of eastern Washington is a typical plateau basalt which is associated toward the west in the Cascade Mountains with a different type of volcanic formation, the Keechelus andesitic series. The latter series has generally been regarded as the younger.

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In the Mount Aix quadrangle the upper part of the Keechelus andesitic series, which has long been known to be unconformable on the lower part, has been split off as a separate unit. This unit, consisting of basic andesite flows and pyroclastics, has been named the Fifes Peak andesite. Marginal flows of the Yakima basalt overlap the Fifes Peak andesite and are clearly younger than the andesite.

The Yakima basalt is generally considered to be middle Miocene. Therefore, the Fifes Peak andesite is presumably not younger than middle Miocene. The lower part of the Keechelus andesitic series may be no younger than Oligocene. The Snoqualmie granodiorite, the intrusion of which has widely altered the lower Keechelus, but apparently has not altered the Fifes Peak andesite or Yakima basalt, is presumably of intermediate age.

GEOLOGY OF THE OKANOGAN VALLEY, WASHINGTON

BY A. C. WATERS

The oldest rocks of the Okanogan Valley in northern Washington constitute a varied series of mildly metamorphic types which Daly named the Anarchist series. They are mainly low-grade metamorphic derivatives of sandstones, shales, graywackes, limestones, and conglomerates. Interbedded with them are great quantities of basic lavas, originally spilites in part, which have been metamorphosed into chlorite schists and greenstones. Metagabbro, metadolerite, and metadiorite are also abundant. Poorly preserved fossils from the middle of the series have been tentatively assigned to the Permian.

Erosion reduced the Anarchist series to a flat surface upon which a thick series of limestones was deposited. The few poorly preserved fossils that have been found indicate a Lower Mesozoic age, probably Triassic, for these limestones. They are complexly deformed and partially metamorphosed.

Malignites and alkalic syenites of various kinds were then intruded and were followed, presumably in the Late Jurassic, by the emplacement of three very large granodiorite batholiths (the Osoyoos, Colville, and Similkameen masses). Between these great intrusives the older metamorphic rocks lie as a broad wedge-shaped septum.

Deep erosion uncovered the batholiths and their wall rocks over wide areas, and spilites and keratophyres were poured out on this surface. After another brief interval continental sediments and andesitic flows and pyroclastics of early Tertiary age were laid down. Erosion to a surface of rugged relief was followed by continental glaciation.

GEOLOGICAL HISTORY OF THE TERTIARY IN THE PACIFIC NORTHWEST

BY CHARLES E. WEAVER

The Tertiary stratigraphic sequence and associated marine invertebrate faunas of Oregon and Washington are closely related to those in the Coast Ranges of California. The maximum thickness of the Tertiary formations in this area is nearly 20,000 feet, although the sequence is not complete in any one section. They are marine and continental, together with thick accumulations of volcanic materials, all of which were deposited on a differentially subsiding coastal plain that permitted the sea to transgress as far east as the present foothills of the Cascades. Still farther east they accumulated as fluviatile and lacustrine sediments. The Lower Eocene is composed of more than 3000 feet of submarine lavas, and upon these rest from 8000 to 14,000 feet of deltaic and marine sand-

stones and shales. These are followed locally by 8000 feet of tuffaceous shaly Oligocene sandstones and in turn, in western Washington and Oregon, by nearly 6000 feet of marine sandstones and intercalated middle Miocene basaltic flows. In late Miocene time all these formations were folded into northwest-trending anticlines which were partially beveled by erosion. The resulting plain was differentially warped downward in western Washington and Oregon, forming several structural basins in which marine sandstones and conglomerates of the Montesano and Empire formations accumulated. At the close of the Tertiary the Coast Ranges, Puget Sound-Willamette depression, and Cascade Mountains were developed as north and south structures superimposed on the older northwest folds.

FORESTS OF ALASKA

BY W. G. WEIGLE

This paper aims to show the value of forests in the development of Alaska, their distribution over the Territory, the character of stand, ecological relations, use and value of the several species, comparison of size and quality with similar species in other timber regions, extent and character of exploitation, and damage from frost, wind, fire, insects, animals, and fungi.

ALASKAN LIVESTOCK RESOURCES AND LIVESTOCK PROBLEMS

BY W. T. WHITE

The first cattle were imported into Alaska 150 years ago from Russia and distributed to a number of settlements. These showed profitable increases only on Kodiak Island.

The interest of the United States generally was not sharply focused on the Territory until the discovery of gold on both sides of the Alaskan-Canadian boundary in 1896. Cattle, sheep, swine, and poultry were shipped to Alaska to support the settlers and miners during the 1898-1910 period. Since that time there has continued some local Alaskan production of livestock and livestock products.

The United States Department of Agriculture progressively established agricultural experiment stations immediately following the gold rush. These were located at Sitka, Copper River, Rampart, Kenai, Fairbanks, and Matanuska. Livestock problems were investigated at the Kodiak and Matanuska stations. Hardy breeds of beef cattle, sheep, and swine have been found suitable for limited portions of the Territory. The aggregate area of Alaska suited for livestock, though only a small percentage of the total area of the Territory, offers considerable promise for this resource, if properly developed. The northern and western Alaskan tundra is well suited to reindeer production. Southwestern Alaska offers the best possibilities for the raising of beef cattle and sheep. The Matanuska valley and adjacent Kenai peninsula appear best suited for dairy cattle, swine, and poultry. The Fairbanks district of the Tanana River valley and the panhandle portion of southeastern Alaska can profitably maintain their local needs of dairy products and swine.

GENERAL FEATURES OF GEOLOGY OF COEUR D'ALENE MINING DISTRICT, IDAHO

BY KEITH WHITING

The Coeur d'Alene Mining District, one of the country's major lead-zinc-silver mining camps, is located in the narrow part of Idaho. It lies on the western slope of the Coeur d'Alene Mountains about 90 miles east of Spokane. The mines of the

district are situated in an area, 20 by 25 miles over all, which is characterized by complex folding and faulting in distinction to the surrounding country in which open folding and minor faulting is the rule. The principal country rocks are fine-grained sericitic quartzites and argillites of the pre-Cambrian Belt Series. The igneous rocks, of minor areal extent, are all intrusive. They consist of narrow diabase and lamprophyre dikes and several stocks of monzonite, which are generally believed to be related to the Idaho batholith, the source magma of the mineralizing solutions.

Although practically all the district's ore deposits are mesothermal and were formed by replacement of siderite, quartz, and country rock along pre-mineral shearing and faulting, together with some fissure filling, it is possible, in a general way, to subdivide the district into several areas in which the structural setting and mineralization are distinct and different.

Recent mining development and geologic study have enhanced the future outlook for the camp, and it is felt that more ore bodies will be found to take the place of those that have been or are being exhausted.

PAPERS PRESENTED AT COLUMBUS (1939) MEETING BUT NOT PREVIOUSLY PUBLISHED

INDUSTRIAL LIMESTONES IN VIRGINIA

BY ARTHUR BEVAN

Virginia contains a great abundance of limestone, dolomite, and other calcareous rocks. Many of them are of great industrial importance, and others have high potential value.

The oldest calcareous rock is pre-Cambrian. It occurs in narrow belts along the western part of the Piedmont province. Most of the industries use material from the Paleozoic limestones and dolomites in the Appalachian Valley in Virginia. Calcareous rocks to meet almost any need can be obtained there, as all grades from calcareous shale to almost chemically pure limestone and from slightly magnesian limestone to typical dolomite are found in abundance. The Border conglomerate limestone facies of the Triassic in the northwestern part of the Piedmont province in Virginia is extensively used locally. Miocene coquina and shell marl are important in parts of the Coastal Plain.

The value of the annual production from the limestones and related rocks in Virginia is next to the largest among the Virginia mineral industries.

SEISMOLOGIST'S DIFFICULTIES WITH SOME MATHEMATICAL THEORY OR THE LACK OF IT

BY PERRY BYERLY

The "refracted" wave of seismic prospecting and near-earthquake seismology is discussed, and it is suggested that differences in elastic constants near boundaries from those in the body may help explain this type of wave. Questions are presented regarding the ratio of thickness of layer to wave length necessary for the application of Snell's law. Certain ideas presented by several authors on elastic waves are questioned.

LOW AND BALL OF THE EASTERN SHORE OF LAKE MICHIGAN

BY O. F. EVANS

"Low and Ball" is a term used to designate the subaqueous troughs and ridges that are formed on certain beaches having an abundance of sand and a gently sloping bottom—for example, the eastern shore of Lake Michigan.

Each low (trough) with its accompanying outer ball (ridge) constitutes a unit which is formed at the depth and position where a line of breakers plunges. The strongest orbital movement occurs underneath the front of the breaker, and sediment is drawn up off the bottom. When the crest of the breaker plunges, the water falls nearly vertically, producing a violent turmoil which throws more sediment into suspension. The suspended material is carried slightly outward by the orbital movement of the water and upward by the escaping air entrapped by the plunging wave front. Part of the material, held in suspension until the approach of the next breaker, forms the ball to windward of the low. These lows and balls do not migrate shoreward but are permanent so long as the conditions of genesis remain unchanged.

If the crest of a ball is brought toward the surface by a fall in water level, the tops of the plunging wave crests give rise to waves and currents of translation, and the ball becomes a shoreward-migrating ridge. For this reason lows and balls are

not ordinarily preserved as beach features on an uplifted coast because, as the water level falls, the balls are driven shoreward by waves and currents of translation and become incorporated with the beach ridge.

ECONOMIC ASPECTS OF INDUSTRIAL MINERAL PRODUCTION

BY RAYMOND B. LADOO

Successful production of many, if not most, industrial minerals depends upon a thorough knowledge of many economic factors. Of these, marketing stands first—equal in importance to the characteristics of the deposit itself. Other important factors, all closely interrelated, are those of place value, transportation, size of plant, condition of the industry, capital requirements, and research. Failure to understand the need for such information and to study these factors in detail before opening deposits and building plants has been responsible for the failure of many enterprises and the cause of serious economic loss. This paper briefly points out why these factors are important and cites examples of the consequences of ignoring them.

PRELIMINARY REPORT ON AN INSTRUMENTAL SEARCH FOR METEORITES

BY LINCOLN LA PAZ

In a recent paper the writer has discussed mathematically the vertical distribution in the earth of iron meteorites treated as spheres. Results obtained in this paper indicate that the amount of meteoritic iron below maximum plow depth may greatly exceed the amount above this level. The need for equipment capable of detecting deeply buried iron meteorites is therefore apparent.

The present paper gives a preliminary account of: (1) the theory and construction of meteorite detectors tested out at Ohio State University since 1930, including instruments of beat frequency oscillator type, balances of Theodorsen's N. A. C. A. bomb-detector type, and portable geophysical prospecting instruments of commercial design; (2) the classes of meteorites (and associated metamorphosed rock) found at depth with the various detectors in a 13,000-mile field trip made in the Spring and Summer of 1939 and financed in part by a grant from the Graduate Council of Ohio State University.

STRUCTURAL HISTORY OF IRON METEORITES

BY J. O. LORD

In this paper the Widmanstätten patterns and other structural features, such as grain size, found in certain iron meteorites are described and illustrated. An attempt is made to suggest interpretations of these structures in terms of the thermal history and age of the meteorites.

GEOLOGY OF PHOSPHATE DEPOSITS IN THE UNITED STATES*

BY GEORGE R. MANSFIELD

Phosphate deposits are the end products of long, progressive concentration by many different agencies and processes from apatite, a mineral found in crystalline rocks. A wide range of inorganic and organic agencies and processes is involved, which, as already shown by Blackwelder, tend to operate in a cycle. Not all deposits reach

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the same stage in the cycle, and there are some short cuts. As illustrations of the process, the geologic histories of the principal types of phosphate in Florida, Tennessee, and Western fields are outlined. Some of the salient facts pertaining to these deposits are given.

SOME PLEISTOCENE TERRACES OF THE MISSISSIPPI RIVER

BY PERCIVAL ROBERTSON

Two Pleistocene terraces of the Mississippi River are described. The Cuivre terrace, named from Cuivre township, Saint Charles County, Missouri, lies approximately at 520 feet. It is composed of stratified sand and silt with some clay, in layers more than a foot in thickness, but top beds are locally varvelike. It was formed in waters imponded by a tongue from the Illinoian ice sheet, which extended westward from Edwardsville to Saint Louis. Distribution of the terrace demonstrates that this tongue moved westward rather than southward from Alton, as shown on some glacial maps. The Cuivre terrace merges with Illinoian outwash at Quincy, and at Chambersburg on the Illinois. It may be followed over 100 miles up the Missouri from its mouth.

The second terrace, named from Festus, Missouri, may be traced from the Bloomington moraine at Peoria, down the Illinois and Mississippi to the Ohio. For 70 miles its gradient is relatively steep but downstream it flattens to 6 inches per mile. The terrace is composed of thinly stratified silt, sand, and clay, with some fine gravel. The overloaded stream built deltalike deposits at the mouths of tributaries, the foreset beds sloping counter to their gradients. Some alterations in drainage ensued when the master stream eroded its flood plain with clearer water that came from the glacial Great Lakes. Two such instances are described. Joachim Creek in the Kimmswick, Missouri, quadrangle captured the headwaters of Sandy Creek; Hubble Creek, near Cape Girardeau, was deflected and became superimposed.

ORIGIN OF HALEAKALA CRATER, MAUI, HAWAII

BY HAROLD T. STEARNS

A geologic map of Haleakala Crater, Maui Island, Hawaii, was finished by the writer in 1935 as part of the systematic geologic investigation of the Hawaiian Islands by the United States Geological Survey in co-operation with the Territory of Hawaii. The crater is 7 miles long and 2 miles wide. The highest point on the rim is 10,025 feet above sea level. The hypothesis is presented that this great "crater" is due chiefly, and perhaps entirely, to stream erosion by the recession of two great amphitheater-headed valleys, Keanae and Kaupo, from opposite sides of the mountain, instead of being due to either collapse, sliding away of a side of the cone, or explosion, as set forth by others. Kipahulu, Waihoi, and Manawainui valleys were likewise formed during this long erosion period. The ancient main rift zone crossed the summit and the heads of Keanae and Kaupo valleys. Renewed volcanic eruptions along this rift built large cinder cones and poured out voluminous flows that nearly masked the ancient divide between the two valleys and partly filled both to the sea. The depth of the fill probably exceeds 2000 feet at the valley heads. The lava flows displaced the drainage channels and caused the streams to undercut their valley walls, thereby widening their heads. Many of the late eruptions took place along fissures crossing the valley walls, thereby giving vent to flows that cascaded down the steep sides. A broad, thick mud flow underlies the late lavas at the mouth of Kaupo Valley.

IMPROVED LABORATORY PROCEDURES: INTRODUCTION TO MINERALS AND ROCKS

BY LINCOLN R. THIESMEYER

The procedure described represents an outgrowth of 10 years of experimentation in introductory courses at several colleges and universities. Some salient features of the method are:

(1) Presentation of descriptive data and directions for procedure in the laboratory manual, rather than in classroom or laboratory lectures.

(2) Arrangement of the work into units larger than single exercises designed for one laboratory session each.

(3) Permitting of students to work through these units at their own speed within maximum time limits specified for each unit.

(4) Consideration of only one physical property at a time and recognition of it in many minerals, rather than identification of one mineral at a time through study of its many properties.

(5) Use of numerous carefully organized and labelled trays of demonstration material to stimulate interest beyond that in materials actually handled by the student and to clarify explanations in the manual with additional examples.

(6) Inclusion of several color varieties of both quartz and feldspar in different parts of the unit on mineral identification to emphasize by repetition their diagnostic properties and to avoid the tendency of students to expect in rock identification that each of these minerals will look like the first (and perhaps only) specimens of them they had ever seen.

(7) Concentration on mineral content only in first work with igneous rocks. Consideration of color, texture, and classification is deferred until students have learned to identify the common minerals in small grain sizes.

(8) Varied procedures in handling unknown specimens.

INDEX TO VOLUME 51 (July-December)*

Page

Abrasion on size, shape, and roundness of rock fragments, Effects of..... *1933*
Abrigo limestone *1964*
Absaroka Mountains, Wyoming, Structural and volcanic problems in Southern..... 1413
Accessory-mineral methods, Studies of Lake Superior pre-Cambrian by..... 1429
ADDISON, C. C., *et al.*: Folded thrust faults in foothills of Alberta..... *1928*
Age determination *1931*
Agricultural future, Alaska's..... *2030*
Ajibik quartzite *1925*
Alabama, Correlation of lower Eocene formations of New Jersey and..... *2009*
Alaska, Forests of..... *2036*
—, Larger physical features of..... *2032*
— Mineral resources of..... *2032*
—, Origin of muck-silt deposits at Fairbanks 1295
—, Regional approach to economic planning in *2017*
—, Salmon fisheries of..... *2020*
—, Stratigraphy of *2033*
—, Submarine mountains in Gulf of..... *1935*
—, Utilization of public lands in..... *2030*
Alaskan livestock resources and livestock problems *2036*
— minerals, Bonneville-Grand Coulee power and *2024*
— weather, Survey of..... *2020*
Alaska's agricultural future *2030*
Alberta, Folded thrust faults in foothills of *1928*
—, New genus of Gastropoda, probable ancestor of Grangerellidae from Upper Cretaceous of *1976*
ALLEN, J. E.: Chromite in Oregon..... *2015*
—: Tectonics of Northern Wallowa Mountains, Oregon *2015*
ALLEN, V. T.: Andalusite in Californian Eocene sediments *1915*
ALLISON, I. S.: Flint's fill hypothesis of origin of Scabland..... *2016*
—: Stratigraphic relations of Willamette Valley fill *2016*
America, Black beach sands of Guatemala, Central *1921*
American defense, Strategic problems of..... *2006*
— outpost, Greenland as an..... *1996*
Anatomy of *Bothriolepis canadensis*, Soft *1968*
Andalusite in Californian Eocene sediments *1919*
Andean geosyncline, Mesozoic..... *1963*
ANDERSON, A. L.: Endomorphism of Idaho batholith *2016*
Andesites of Oregon.....*1959*
Andesitic rocks of Cascade Mountains, Relation of Plateau basalts of eastern Washington to *2034*
Anson County, North Carolina, Triassic of *1920*
APPEL, E. T., AND FLINT, R. F.: Proposed glacial map of North America..... *1926*
Appalachian orogeny, Joint patterns in highly folded and crystalline rocks and their relation to *1919*
— — and sedimentation *1999*
— peridotite belt: its significance in sequence of events in mountain building..... *1996*
Appalachians, Silurian of central..... *2008*
Appendages of rhipidist fishes and their bearing on origin of tetrapod limbs, Relations of preaxial and postaxial borders in paired *1971*
Appleby, A. N.: Joint patterns in highly folded and crystalline rocks of northern New Jersey Highlands and their relation to Appalachian orogeny..... *1919*

Page

Appropriate political control of nation's defense resources *2011*
Archean metaconcretions of Thunder Lake, Ontario 1841
— sedimentation *1938*
Archimedes, Progress in study of..... *1968*
Arcuate structures, Validity of four additional classes of *1998*
Arizona, Empire Mountains *1927*
—, Ep-Archean and Ep-Algonkian erosion surfaces, Grand Canyon..... 1235
—, Paleozoic paleogeography of..... *1959*
—, Pediment gaps of Sacaton Mountains.... *1930*
ARMSTRONG, ELIZABETH: Hybridization and shearing in banded gneisses near Philadelphia *1989*
Aroostook County, Maine, Silurian stratigraphy of *1978*
Artifacts and associated fossils from Bee County, Texas, Pleistocene 1627
Asia, Geological observations in Lebanon Mountains of *1951*
Association of pyroxene granite and serpentine near Lima, Pennsylvania..... *2002*
Astrodapsis on West Coast, Evolution of genus *1981*
Atlantic, Foraminifera of submarine cores from North *1975*
— Coastal Plain, Geophysical investigations in emerged and submerged Atlantic Coastal Plain.....1821
— — —, Magnetic investigations in..... *2013*
Aucella-bearing beds of California Coast Ranges, Stratigraphic study of..... *1986*
Audubon-Albion stock, Boulder County, Colorado 1789
Avenal sandstone (Middle Eocene) of Reef Ridge, California, Foraminiferal faunule from *1982*
AVERILL, C. V.: Economic geology of California and southern Oregon..... *2017*

BAILEY, E. H.: Piedmontite and kyanite from Franciscan of Santa Catalina Island.... *1954*
BAILEY, E. H., *et al.*: Treanorite, a new mineral from Crestmore, California..... *1965*
BAIN, G. W.: Granitization in western New England *1989*
Balcony Falls, Virginia, Interpretation of cross section of Blue Ridge north of..... *1990*
BALL, J. R.: Elongate drift hills of southern Illinois 951
Bare Mountain, Nevada, Welded tuff resembling vitrophyre and pitchstone..... *1957*
BARKSDALE, J. D., *et al.*: Puget Sound earthquake of November 12, 1939..... *2017*
Barnacles from Southern California, Miocene sessile *1987*
BARNES, V. E.: Distribution and origin of tektites *1919*
Barrier beach formation at Long Beach, California *1957*
Barstow formations, New evidence on faunal relations of Ricardo, Mint Canyon, and *1986*
Basalt series, Koolau..... *1963*
Basaltic glass at Safe Harbor, Pennsylvania, Triassic dikes of *2009*
Basalts of eastern Washington, Relation to andesitic rocks of Cascade Mountains.. *2034*
Basins, Hydro-physical approach to quantitative morphology of drainage..... *1996*
BASSLER, R. S., AND MOODEY, M. W.: Bibliographic and faunal index of Paleozoic Pelmatozoa *1967*
Batholith, Endomorphism of Idaho..... *2016*
—, Structural problems of east border of Colville *2019*

* Page numbers of abstracts are in *italics*.

Page

BAUER, H. A.: Regional approach to economic planning in Alaska.... 2017
Baylor County, Texas, "Bone pocket" in Lower Permian Lueders formation of... 1975
Beach formation at Long Beach, California 1957
— sands of Guatemala, Central America, Black 1921
— — on Gulf Coast of Texas, Source of.... 1922
Bearpaw Mountains, Montana, Structure and petrology of Boxelder laccolith.... 1937
BECK, G. F.: Late Tertiary stratigraphy and paleontology of south-central Washington and adjacent Oregon.... 2018
Bee County, Texas, Pleistocene artifacts and associated fossils from.... 1627
BELL, W. C.: Key brachiopod faunas in Cambrian of Montana.... 1967
Bellerophontid gastropods, Pennsylvanian... 1973
BENNETT, W. A. G.: Structural features of Washington magnesite 2018
—: Ultrabasic rocks of Twin Sisters Mountains, Washington 2019
BENTSON, HERBIS, AND KEEN, A. M.: Check list of California Tertiary marine Mollusca 1972
BERRY, WILLARD: Triassic of Anson County, North Carolina 1920
BERTHIAUME, S. A., AND MERRIAM, C. W.: Late Paleozoic history of central Oregon 1935
BEVAN, ARTHUR: Industrial limestones in Virginia 2039
Bibliographic and faunal index of Paleozoic Pelmatozoa 1967
— index of Permian invertebrates.... 1967
Big Horn Montains, Thrust faulting at.... 1934
BILLINGS, M. P.: Paleozoic igneous activity in New England 1990
— AND SPIEKER, E. M.: Glaciation in Wasatch Plateau, Utah 1173
BILLINGSLEY, PAUL, AND LOCKE, AUGUSTUS: Regional correlation of structural elements-problems: western United States 1955
BISSELL, H. J.: Organic content of cores from Gulf of Mexico off Mississippi Delta.... 1920
Black beach sands of Guatemala, Central America 1921
— Hawk Ranch Quarry fauna: value of large collections in mammalian paleontology.. 1985
— River stratigraphy in Tazewell County, Virginia 1924
BLACKWELDER, ELIOT: Crystallization of salt as a factor in rock weathering.... 1956
—: Desert floods in action.... 1955
BLOOMER, R. O.: Interpretation of cross section of Blue Ridge north of Balcony Falls, Virginia 1990
Blue Ridge north of Balcony Falls, Virginia, Interpretation of cross section of.... 1990
BODE, F. D.: Geology of San Joaquin Hills, Orange County, California.... 1956
BOGGS, S. W.: Mapping the changing world: suggested improvements in maps.... 1990
Bomb craters in different soils.... 1922
"Bone pocket" in Lower Permian Lueders formation of Baylor County, Texas.... 1975
Bonneville-Grand Coulee power and Alaskan minerals 2024
BOOS, M. F.: Black Beach sands of Guatemala, Central America.... 1921
Bothriolepis canadensis, Soft anatomy of.... 1968
Boxelder laccolith, Bearpaw Mountains, Montana, Structure and petrology of.... 1937
Brachiopod faunas in Cambrian of Montana, Key 1967
BRADFORD, D. C., *et al.*: Puget Sound earthquake of November 12, 1939.... 2017
BRANSON, C. C.: Bibliographic index of Permian invertebrates 1967
BRANSON, E. B., AND MEHL, M. G.: New Ordovician conodont faunas.... 1968

Page

BRAY, J. M.: Spectroscopic distribution of minor elements in igneous rocks from Jamestown, Colorado 1921
BRIDGE, JOSIAH: Correlation of early Paleozoic sections in central and western Texas.. 1921
Browns Point formation, Olympic Peninsula, Washington 2022
BRUFF, S. C.: Pleistocene history of Newport Bay area, southern California.... 1981
BRYAN, G. S.: Geography and defense of Caribbean and Panama Canal.... 1991
Buffalo Hump, Orbicular rock from.... 1928
BULLARD, F. M.: Source of beach sands on Gulf Coast of Texas.... 1922
Burma-Yunnan road, Geographic aspects of 1993
BURWASH, E. M. J.: Bomb craters in different soils 1922
BUTLER, R. D., AND RILEY, L. B.: Ore-bearing pipes in Tarryall Range, Colorado.... 1923
BYERLY, PERRY: Seismologist's difficulties with some mathematical theory or lack of it 2039
Byram gneiss in Pennsylvania.... 1994

Caliche, Origin of.... 1939
— karst 1938
California, A new mineral from Crestmore 1965
—, Barrier beach formation at Long Beach 1957
—, Eocene stellate orbitoidal Foraminifera from type Tejon formation, Grapevine Canyon 1984
—, Foraminiferal faunule from Avenal sandstone (Middle Eocene) of Reef Ridge.... 1982
—, Fossil fish from Miocene of Palos Verdes Hills 1982
—, Geology of San Joaquin Hills.... 1956
—, Melanite-nepheline syenite from Panamint Range 1961
—, Miocene sessile barnacles from southern 1987
—, Nephrite jade from.... 1941
—, Origin of quartz veins at Grass Valley.. 1931
—, *Palaeocyclus porpita*, Silurian coral from Panamint Range 1984
—, Pleistocene history of Newport Bay area, southern 1981
—, Pliocene and Pleistocene fossils at Rincon Creek, Santa Barbara County.... 1981
—, Quaternary geology of June Lake district 1939
—, Section across Commercial Quarry.... 1966
—, Strategic position in geology and mineral industry 2025
—, Stratigraphic occurrence of *Pecten sanctaecruzensis* in 1933
—, Structural features of Virgin Spring area, Death Valley 1936
—, Subsurface structure of San Joaquin Valley 1957
—, Two new Pliocene formations in.... 1956
—, Upper Miocene fish from northern rim of Santa Monica Mountains.... 1982
— and southern Oregon, Economic geology of 2017
— Coast Ranges, Stratigraphic study of *Aucella*-bearing beds of.... 1986
— ring dike 1961
— Tertiary marine Mollusca, Check list of.. 1972
Californian Eocene sediments, Andalusite in 1919
Calvert Miocene in Maryland, Mollusks of.. 2006
Cambrian geography and sedimentation in central Cordilleran region.... 2021
— of Montana, Key brachiopod faunas in.. 1967
— *Skolithos* and *Planolites* at Reading, Pennsylvania 1972
CAMPBELL, C. D.: Low-grade metamorphism of Covada sediments along Columbia River 2019
—: Structural problems of east border of Colville batholith 2019
CAMPBELL, IAN, AND MAXSON, J. H.: Intracanyon lava flow of lower granite gorge, Grand Canyon 1958
Canaan area, New Hampshire, Glacial deposits of 1924

Page

Canada, Discovery of a marine fauna in Eastend formation of Saskatchewan.... 1976
Canadian cephalopods: Part 1, Nautilicones, Ozarkian and 1979
Cannonball marine beds in North Dakota, Foraminiferal evidence for Midway (Paleocene) age of 1970
Cape May, New Jersey, Geophysical investigations in emerged and submerged Atlantic Coastal Plain 1821
— — formation, Marine topography of..... 2002
Caribbean, Geography and defense of..... 1991
Carolina tin belt, Genetic history of pegmatites and associated rocks of..... 1999
CARPENTER, A. B.: Survey of Alaskan weather 2020
Cascade andesites of Oregon..... 1959
— Mountains, Relation of Plateau basalts of eastern Washington to andesitic rocks of 2034
Cascades, Structure and petrography of Oregon 2025
Cedar–Snoqualmie area, Glacial geology of. 2028
CEDERSTROM, D. J.: Geology and hydrology of Saint Croix, Virgin Islands..... 1992
—: — — — — southeastern Virginia Coastal Plain 1992
Central America, Black beach sands of Guatemala 1921
Cephalopoda from New Mexico, Pennsylvanian Scaphopoda and..... 1979
Cephalopods: Part 1, Nautilicones, Ozarkian and Canadian 1979
CHADWICK, G. H.: Columnar limestone produced by sun-cracking 1923
CHAFFEE, R. G.: Indications of Cretaceous New Jersey shore lines 1992
Changes of level in western and southern Newfoundland, Late Quaternary..... 1757
Channels in Late Pleistocene ice recession, Significance of hillside 1933
CHAPMAN, R. W.: Origin of Laurel migmatite 1992
Chazyan and Black River stratigraphy in Tazewell County, Virginia 1924
Check list of California Tertiary marine Mollusca 1972
Cheyenne Mountain overthrust, Colorado... 1942
Chico formation, Type locality of Cretaceous 1311
Chile, Nitrate deposits of Tarapacá..... 1941
Choptank Miocene in Maryland, Mollusks of 2006
Chromite in Oregon 2015
CHURCH, VICTOR, *et al.*: Structural types and trends in central western Wyoming..... 1930
CLAPP, A. D.: Foraminifera of Miocene of Maryland 1993
CLARK, B. L.: Evolution of genus *Astrodapsis* on West Coast 1981
—: Two new Pliocene formations in California 1956
Clastic dikes in Lewiston Basin, Washington and Idaho, Origin of 2027
CO_2-H_2O-K_2O-SiO_2, Equilibrium between vapor and liquid phases in system..... 1035
Coal distribution and transportation in war time, Problems of..... 2011
Coastal Plain, Geology and hydrology of southeastern Virginia 1992
— —, Geophysical investigations in emerged and submerged Atlantic (Cape May, N. J., section) 1821
— —, Heavy minerals and history of..... 1993
— —, Magnetic investigations in Atlantic... 2013
— —, Pliocene Equidae of Texas Gulf..... 1970
— — in New Jersey, Composition and structure of 1998
— Plains area of Texas, Cretaceous-Tertiary relationships in 2006
Coeur D'Alene district, Influence of structure on ore deposits of..... 2029
— — mining district, Idaho, Geology of..... 2036

Page

COLE, TAYLOR: Subsurface study of Ellenberger formation in west Texas..... 1923
Colorado, Cheyenne Mountain overthrust... 1942
—, Distribution of minor elements in igneous rocks from Jamestown 1921
—, Hydrothermal deposits in Specimen Mountain volcanics 1951
—, Ore-bearing pipes in Tarryall Range.... 1923
— Front Range, Rock glaciers in..... 1271
— River system in Grand Canyon 1961
Columbia Plateau, Glacial drainage changes north of 2021
— River, Low-grade metamorphism of Covada sediments along..... 2019
Columnar limestone produced by sun-cracking 1923
Colville batholith, Structural problems of east border of 2019
Commercial Quarry, California..... 1965
Complex structures of New River Basin..... 2002
Complexes and orogenies in western North America, Pre-Cambrian igneous 1958
Composition and structure of Coastal Plain in New Jersey 1998
Concentric patterns in granites of Llano-Burnet region, Texas 971
Conditions favoring recrystallization, Experimental flow of rocks under 1001
CONDRA, G. E.: Progress in study of *Archimedes* 1968
Conglomerate as a Triassic outlier in Pennsylvania, Spitzenberg 2011
Connate waters, Gravity versus "volatile transfer" differentiation and 2000
— — in West Virginia, Origin and geochemistry of 1995
Conodont faunas, New Ordovician 1968
Control of nation's defense resources, Appropriate political 2011
COOMBS, H. A., *et al.*: Puget Sound earthquake of November 12, 1939..... 2017
COOPER, B. N., AND PROUTY, C. E.: Chazyan and Black River stratigraphy in Tazewell County, Virginia 1924
COOPER, J. C., AND STURDEVANT, R.: Pliocene and Pleistocene fossils at Rincon Creek, Santa Barbara County, California..... 1981
Copper belt, Geology of Shasta 2031
Copple Crown area, New Hampshire, Igneous rocks of..... 1940
Coral faunas of Washington, Eocene and Oligocene 1983
— from Panamint Range, California, *Palaeocyclus porpita*, Silurian 1984
Corals from North America, Permian..... 1974
Cordillera, Diversity of Eparchean interval over 1960
Cordilleran region, Cambrian geography and sedimentation 2021
Cores from Gulf of Mexico, Organic content of 1920
— — — — — off Mississippi delta 1943
— — North Atlantic, Foraminifera of submarine 1975
Correlation and significance of Mictaw fauna of Gaspé 1974
— of Early Paleozoic sections in central and western Texas 1921
— — lower Eocene formations of New Jersey and Alabama 2009
— — structural elements-problems; western United States 1955
Cortland complex, Phase petrology in..... 1944
Coso Hot Springs area, Geology and quicksilver deposits of..... 1965
Course on geography of national defense..... 2010
Covada sediments along Columbia River, Low-grade metamorphism of 2019
Crater, Odessa meteor 1944
—, Origin of Haleakala 1948
Craters in different soils, Bomb..... 1922

Page

Crestmore, California, A new mineral from.. 1965
— —, Commercial Quarry 1965
Cretaceous and paleoecological significance, Pyrite faunas of Washita and Eagle Ford groups of Texas 1977
— Chico formation, Type locality of..... 1311
— New Jersey shore lines, Indications of.... 1992
— of Alberta, New genus of Gastropoda, probable ancestor of Grangerellidae from Upper 1976
— pelecypods of *Venericardia beaumonti* group from Iran, Upper..... 1976
— Rocky Mountain nonmarine microfossils, Lower 1974
— -Tertiary relationships in Coastal Plains area of Texas..... 2006
— — — — northern South America 1995
CRIPPEN, R. A., *et al.*: Section across Commercial Quarry, Crestmore, California.. 1965
Criteria for distinguishing orthomagmatic from metasomatic rocks 2023
CROSS, C. M., *et al.*: Type locality of Cretaceous Chico formation 1311
Cross section of Blue Ridge north of Balcony Falls, Virginia 1990
CRUME, R. W.: Foraminiferal faunule from Avenal sandstone (Middle Eocene) of Reef Ridge, California 1982
Crystalline rocks of northern New Jersey Highlands, Jointed patterns in highly folded 1919
Crystallization of salt as a factor in rock weathering 1956

Dakota, Foraminiferal evidence for Midway (Paleocene) age of Cannonball marine beds in North 1970
Data on Saratoga mineral waters, Geochemical 2008
DAVID, LORE: Fossil fish from Miocene of Palos Verdes Hills, California 1982
—: Upper Miocene fish from northern rim of Santa Monica Mountains, California.. 1982
DAVIDSON, F. A.: Salmon fisheries of Alaska 2020
Death Valley, Structural features of Virgin Spring area 1936
Defense, Course on geography of national.... 2010
—, Geographical material in libraries of U. S. with special reference to National.. 2004
—, Strategic problems of American..... 2006
— of Caribbean and Panama Canal..... 1991
— resources, Political control of nation's.... 2011
DEISS, CHARLES: Cambrian geography and sedimentation in central Cordilleran region 2021
DELO, D. M.: Recent recession of Dinwoody Glaciers, Wind River Mountains, Wyoming 1924
DENISON, R. H.: Soft anatomy of *Bothriolepis canadensis* 1968
DENNY, C. S.: Glacial deposits of Canaan area, New Hampshire 1924
Deposits in the United States, Geology of phosphate 2040
Desert floods in action 1955
DE TERRA, HELMUT: Geographic aspects of Burma-Yunnan road 1993
Diabase, Differentiation of Palisade..... 1059
— sills at Duluth, Minnesota, Rock series in 1135
Differentiation of Palisade diabase..... 1059
Dikes in Lewiston Basin, Washington and Idaho, Origin of clastic..... 2027
— of basaltic glass at Safe Harbor, Pennsylvania, Triassic 2009
Dinwoody Glaciers, Recent recession of..... 1924
Discosoroidea (Nautiloides), Superfamily.... 1969
Discovery of a marine fauna in Eastend formation of Saskatchewan, Canada..... 1976
Disperse phase of emulsion, Ellipsoidal structure as gigantic..... 2022
Distribution and origin of tektites..... 1919

Page

Distribution of historic earthquakes in Pacific Northwest 2034
— — igneous rock in Olympic Peninsula, Washington, New data on 2023
— — Petersburg granite in southeastern Piedmont, Virginia 2004
Disturbance, Taconic 1932
Diversity of Eparchean interval over Cordillera 1960
Dolomite, Petrofabric analysis of 1926
Drainage basins, Hydro-physical approach to quantitative morphology of..... 1996
— changes north of the Columbia Plateau, Glacial 2021
Drift hills of southern Illinois, Elongate..... 951
DRYDEN, CLARISSA, AND DRYDEN, LINCOLN: Heavy minerals and history of Coastal Plain 1993
DRYDEN, LINCOLN, AND DRYDEN, CLARISSA: Heavy minerals and history of Coastal Plain 1993
Duluth, Minnesota, Rock series in diabase sills at 1135
Dune form and wind direction along southern shore of Lake Michigan..... 1947
DURHAM, J. W.: Eocene and Oligocene coral faunas of Washington 1983
Dynamic metamorphism, Experiments in.... 1928

Eagle Ford groups of Texas Cretaceous and paleoecological significance, Pyrite faunas of Washita and 1977
Earth, Internal heat of 1946
—, Seismicity of 1958
— motions in vicinity of a fault slip..... 1929
Earthquake of November 12, 1939, Puget Sound 2017
Earthquakes in Pacific Northwest, Distribution of historic 2034
Eastend formation of Saskatchewan, Canada, Discovery of a marine fauna in..... 1976
Economic aspects of industrial mineral production 2040
— geology of California and southern Oregon 2017
— planning in Alaska, Regional approach to 2017
EDMUNDSON, R. S.: Subordinate structures of Massanutten Mountain syncline in northern Virginia 1994
EDWARDS, K. L.: Stratigraphic occurrence of *Pecten sanctaecruzensis* in California..... 1983
Effects of abrasion on size, shape, and roundness of rock fragment 1933
EKBLAW, G. E., AND POWERS, W. E.: Glaciation of Grays Lake, Illinois, quadrangle.. 1329
ELIAS, M. K.: Tertiary grasses and other herbs from High Plains 1969
—: Trend of changes in Late Tertiary prairie 1925
Ellenberger formation in west Texas, Subsurface study of 1923
Ellipsoidal structure as gigantic disperse phase of emulsion 2022
Elongate drift hills of southern Illinois..... 951
Empire Mountains, southeastern Arizona.... 1927
Emulsion, Ellipsoidal structure as gigantic disperse phase of 2022
Endomorphism of Idaho batholith 2016
ENGLISH, W. A.: Subsurface structure of San Joaquin Valley, California..... 1967
Eocene, Sedimentation in Gulf Coast..... 1949
— and Oligocene coral faunas of Washington 1983
— (Lower) formations of New Jersey and Alabama, Correlation of 2009
— sediments, Andalusite in Californian..... 1919
— stellate orbitoidal Foraminifera from type Tejon formation, Grapevine Canyon, California 1984
Ep-Algonkian erosion surfaces, Grand Canyon, Arizona, Ep-Archean and..... 1235
Ep-Archean and Ep-Algonkian erosion surfaces, Grand Canyon, Arizona..... 1235
— interval over Cordillera 1960

Page

Epochs of volcanism in Salt Lake City region *2031*
Equidae from San Antonio Mountains near Tonopah, Nevada, Upper Miocene..... *1983*
— of Texas Gulf Coastal Plain, Pliocene.... *1970*
Equilibrium between vapor and liquid phases in system CO_2-H_2O-K_2O-SiO_2..... 1035
Erosion surfaces, Grand Canyon, Arizona, Ep-Archean and Ep-Algonkian 1235
Eusthenopteron and its bearing on evolution of paired fins, New reconstruction of skeleton of *1971*
EVANS, O. F.: Low and ball of eastern shore of Lake Michigan *2039*
EVANS, R. D., AND GOODMAN, CLARK: Measurement of terrestrial radioactivities..... *1927*
Evidence of sulfide-silicate immiscibility.... *2003*
Evolution of genus *Astrodapsis* on West Coast *1981*
— — paired fins, New reconstruction of skeleton of *Eusthenopteron* and its bearing on *1971*
EWERS, J. D., AND MOORE, R. C.: Growth stages of *Symbathocrinus* *1973*
EWING, MAURICE, *et al.*: Geophysical investigations in emerged and submerged Atlantic Coastal Plain, Part IV, Cape May, New Jersey, section 1821
Exhibit of stratigraphy and structural forms of Texas-Louisiana Gulf Coast..... *1952*
Experimental flow of rocks under conditions favoring recrystallization 1001
Experiments in dynamic metamorphism..... *1928*

FAIRBAIRN, H. W.: Petrofabric notes on quartz lamellae in Ajibik quartzite, Michigan *1925*
— AND HAWKES, H. H.: Petrofabric analysis of dolomite *1926*
Fairbanks, Alaska, Origin of muck-silt deposits at 1295
Fault slip, Earth motions in vicinity of..... *1929*
Faulting at southern end of Big Horn Mountains *1934*
— in Triassic of New Jersey, Major..... *1994*
Faults in foothills of Alberta..... *1928*
Fauna: value of large collections in mammalian paleontology, Black Hawk Ranch Quarry *1986*
— in Eastend formation of Saskatchewan, Canada, Discovery of a marine..... *1976*
— of Gaspé, Correlation and significance of Mictaw *1974*
Faunal index of Paleozoic Pelmatozoa, Bibliographic and *1967*
— relations of Ricardo, Mint Canyon, and Barstow formations, New evidence on the *1986*
Faunas, New Ordovician conodont..... *1968*
— in Cambrian of Montana, Key brachiopod *1967*
— of New River Basin, Paleozoic *1973*
— — Washington, Eocene and Oligocene coral *1983*
— — Washita and Eagle Ford groups of Texas Cretaceous and paleoecological significance, Pyrite *1977*
Faunule from Avenal sandstone (Middle Eocene) of Reef Ridge, California, Foraminiferal *1982*
FEITLER, STANLEY: Welded tuff resembling vitrophyre and pitchstone at Bare Mountain, Nevada *1957*
Fill, Stratigraphic relations of Willamette Valley *2016*
— hypothesis of origin of scabland, Flint's.. *2016*
Fins, New reconstruction of skeleton of *Eusthenopteron* and its bearing on evolution of paired *1971*
Fish from Miocene of Palos Verdes Hills, California, Fossil *1982*
— — northern rim of Santa Monica Mountains, California, Upper Miocene..... *1982*
Fisheries of Alaska, Salmon *2020*

Page

Fishes, Texas fossil *1971*
— and their bearing on origin of tetrapod limbs, Relations of preaxial and postaxial borders in paired appendages of rhipidist *1971*
FLEISCHER, M., AND MOREY, G. W.: Equilibrium between vapor and liquid phases in system CO_2-H_2O-K_2O-SiO_2..... 1035
FLINT, R. F.: Late Quaternary changes of level in western and southern Newfoundland 1757
— AND APPEL, E. T.: Proposed glacial map of North America *1926*
Flint's fill hypothesis of origin of scabland.. *2016*
Floods in action, Desert *1955*
"Flow" in stressed solids: an interpretation.. 1023
FLOWER, R. H.: Superfamily Discosoroidea (Nautiloidea) *1969*
FOERSTE, A. F., *et al.*: Ozarkian and Canadian cephalopods: Part 1, Nautilicones..... *1979*
Folded thrust faults in foothills of Alberta.. *1928*
Folds, Stratigraphic measurements in parallel 1107
Foraminifera from type Tejon formation, Grapevine Canyon, California, Eocene stellate orbitoidal *1984*
— of Miocene of Maryland *1993*
— — submarine cores from North Atlantic.. *1975*
Foraminiferal evidence for Midway (Paleocene) age of Cannonball marine beds in North Dakota *1970*
— faunule from Avenal sandstone (Middle Eocene) of Reef Ridge, California..... *1982*
Forests of Alaska *2036*
Fossil fish from Miocene of Palos Verdes Hills, California *1982*
— fishes, Texas *1971*
— localities in Texas, New *1977*
Fossils at Rincon Creek, Santa Barbara County, California, Pliocene and Pleistocene *1981*
Four-phase volcanism in Hawaii..... *1947*
FOX, S. K., JR., AND ROSS, R. J., JR.: Foraminiferal evidence for Midway (Paleocene) age of Cannonball marine beds in North Dakota *1970*
Franciscan of Santa Catalina Island..... *1955*
FRASER, D. M.: Pochuck, Byram, and Losee gneisses in Pennsylvania *1994*
FREEDMAN, JACOB, AND ROY, C. J.: Petrology of Pawtuckaway Mountains, New Hampshire *1942*
FREEMAN, O. W.: Fundamental bases of Northwest geography *2021*
—: Glacial drainage changes north of Columbia Plateau *2021*
Front Range, Rock glaciers in Colorado..... 1271
FULLER, R. E.: Ellipsoidal structure as gigantic disperse phase of emulsion..... *2022*
Fundamental bases of Northwest geography.. *2021*
FURNISH, W. M., *et al.*: Ozarkian and Canadian cephalopods: Part 1, Nautilicones.. *1979*
Further evidence of Reading overthrust..... *2007*
— observations on Lower Paleozoic sequence of western Newfoundland *1998*

GALBRAITH, F. W.: Empire Mountains, southeastern Arizona *1927*
Gaps of Sacaton Mountains..... *1930*
GARNE, K. B., *et al.*: Section across Commercial Quarry, Crestmore, California... *1965*
Gaspé, Correlation and significance of Mictaw fauna of *1974*
Gastropoda, probable ancestor of Grangerellidae from Upper Cretaceous of Alberta, New genus of *1976*
Gastropods, Pennsylvanian bellerophontid... *1973*
General features of geology of Coeur D'Alene mining district, Idaho *2036*
Genetic history of pegmatites and associated rocks of Carolina tin belt..... *1999*
Geochemical data on Saratoga mineral waters *2008*

Page
Geochemistry of connate waters in West Virginia 1995
Geographic aspects of Burma-Yunnan road.. 1993
Geographical materials in libraries of U. S. with especial reference to national defense 2004
Geography, Bases of Northwest..... 2021
— and defense of Caribbean and Panama Canal 1991
— — sedimentation in central Cordilleran region, Cambrian 2021
— of National defense 2010
Geologic history of Guam..... 1948
— structure, Trans-continental profile of North America and its relation to..... 1954
Geological history of Tertiary in Pacific Northwest 2035
— museum of future 1997
— observations in Lebanon Mountains of eastern Asia 1951
— subsurface studies 1951
Geology and hydrology of Saint Croix, Virgin Islands 1992
— — — — southeastern Virginia Coastal Plain 1992
— — mineral industry, Strategic position of California in 2025
— — quicksilver deposits of Coso Hot Springs area 1965
— of California and southern Oregon, Economic 2017
— — Coeur D'Alene mining district, Idaho.. 2036
— — Okanogan Valley, Washington 2035
— — phosphate deposits in United States... 2040
— — Portland, Oregon, area 2034
— — San Joaquin Hills, Orange County, California 1956
— — Shasta copper belt 2031
— — Snoqualmie-Cedar area, Glacial..... 2028
Geophysical investigations in emerged and submerged Atlantic Coastal Plain, Part IV, Cape May, New Jersey, section..... 1821
Geosyncline, Mesozoic Andean 1963
Glacial boundary in northeastern Ohio, New evidence for an Illinoian 1337
— chronology of Southern Rocky Mountains 1851
— deposits of Canaan area, New Hampshire 1974
— drainage changes north of Columbia Plateau 2021
— geology of Snoqualmie-Cedar area..... 2028
— history of southeastern Washington..... 2024
— Lake Missoula, Montana, Ripple marks (?) in 2028
— map of North America, Proposed..... 1926
Glaciation in Killbuck Valley south of Millersburg, Ohio, Illinoian 1997
Glaciation in Wasatch Plateau, Utah..... 1173
— of Grays Lake, Illinois, quadrangle..... 1329
— — Newfoundland, Wisconsin 1729
Glaciers, Recent recession of Dinwoody..... 1924
— in Colorado Front Range, Rock..... 1271
Glass at Safe Harbor, Pennsylvania, Triassic dikes of basaltic 2009
Glover, S. L.: Browns Point formation, Olympic Peninsula, Washington..... 2022
—: New data on distribution of igneous rock in Olympic Peninsula, Washington..... 2023
Gneisses near Philadelphia, Hybridization and shearing in banded 1980
Golconda, Nevada, Tungsten-bearing manganese deposit at 1359, 2026
Goodman, Clark, and Evans, R. D.: Measurement of terrestrial radioactivities.... 1927
— — Hurley, P. M.: Investigation of helium retention in common rock minerals for purpose of age determination..... 1931
Goodspeed, G. E.: Criteria to aid in distinguishing orthomagmatic from metasomatic rocks 2023
—: Orbicular rock from Buffalo Hump, Idaho 1928

Page
Goranson, R. W.: "Flow" in stressed solids: an interpretation 1023
Grand Canyon, Arizona, Ep-Archean and Ep-Algonkian erosion surfaces..... 1235
— —, Colorado River system in..... 1961
— —, Intra-canyon flow of lower granite gorge 1956
— Coulee-Bonneville power and Alaskan minerals 2024
Grangerellidae from Upper Cretaceous of Alberta, New genus of Gastropoda, probable ancestor of..... 1976
Granite and serpentine near Lima, Pennsylvania, Association of pyroxene..... 2002
— gorge, Grand Canyon, Lava flow of..... 1956
— in southeastern Piedmont, Virginia, Distribution of Petersburg 2004
Granites of Llano-Burnet region, Texas, Concentric patterns in 971
Granitic rocks of Philadelphia area..... 2004
Granitization in western New England..... 1989
Grant, U. S.: Barrier beach formation at Long Beach, California 1957
Grapevine Canyon, California, Eocene stellate orbitoidal Foraminifera from type Tejon formation 1984
Grass Valley, California, Origin of quartz veins at 1931
Grasses and other herbs from High Plains, Tertiary 1969
Gravels in Raritan Valley, New Jersey..... 2001
Gravitational profile of North America, Trans-continental 1954
Gravity section across Sierra Nevada..... 1391
— versus "volatile transfer" differentiation and connate waters 2000
Grays Lake, Illinois, quadrangle, Glaciation of 1329
Great Basin Ranges, Physiography of..... 1960
— Plains, Paleontological evidence regarding Pliocene-Pleistocene boundary in..... 1943
— —, Sedimentation in relation to 1934
Greenland as an American outpost..... 1996
Gregory, J. T.: Pliocene Equidae of Texas Gulf Coastal Plain 1970
Gregory, W. K.: New reconstruction of skeleton of *Eusthenopteron* and its bearing on evolution of paired fins..... 1971
— and Raven, H. C.: Relations of preaxial and postaxial borders in paired appendages of rhipidist fishes and their bearing on origin of tetrapod limbs..... 1971
Griggs, David: Experimental flow of rocks under conditions favoring recrystallization 1001
—: Experiments in dynamic metamorphism.. 1928
Ground-water problems in Pacific Northwest 2029
Grout, F. F., *et al.*: Studies of Lake Superior pre-Cambrian by accessory-mineral methods 1439
Growth stages of *Symbathocrinus* 1978
Guam, Geologic history of 1948
Guatemala, Central America, Black beach sands of 1921
Gulf Coast, Exhibit of stratigraphy and structural forms of Texas-Louisiana.... 1952
— — as a classic region in study of sedimentation 1949
— — Eocene, Sedimentation in 1949
— — of Texas, Source of beach sands on.... 1922
— Coastal Plain, Pliocene Equidae of Texas 1970
— — —, Relation of stream terraces in Texas to formations of 1952
— of Mexico, Organic content of cores from 1920
Gutenberg, Beno, and Richter, C. F.: Seismicity of earth 1958

Hake, B. F., *et al.*: Folded thrust faults in foothills of Alberta 1923
Haleakala Crater, Origin of 1948

Page

HANNA, G. D., *et al.*: Type locality of Cretaceous Chico formation 1311
HARE, C. E., *et al.*: Origin and geochemistry of connate waters in West Virginia..... 1995
Harrisonburg quadrangle, Topography..... 2009
Hawaii, Four-phase volcanism in..... 1947
—, Koolau basalt series, Oahu..... 1953
—, Origin of Haleakala Crater, Maui..... 1948
HAWKES, H. H., AND FAIRBAIRN, H. W.: Petrofabric analysis of dolomite 1926
HAWKINS, A. C.: Major faulting in Triassic of New Jersey 1994
Heat of earth 1948
Heavy minerals and history of Coastal Plain 1993
HECK, E. T., *et al.*: Origin and geochemistry of connate waters in West Virginia..... 1995
HECK, N. H., AND NEUMANN, FRANK: Earth motions in vicinity of a fault slip..... 1929
HEDBERG, H. D.: Cretaceous-Tertiary relationships in northern South America..... 1995
Helderberg (Upper)—Oriskany relations in West Virginia 2012
Helium retention for age determination..... 1931
HELLMAN, N. N., AND MCKELVEY, V. E.: Pipette-hydrometer method for size analysis 1929
HENDRY, N. W., AND WILSON, H. D. B.: Geology and quicksilver deposits of Coso Hot Springs area 1965
HENSHAW, P. C.: Upper Miocene Equidae from San Antonio Mountains near Tonopah, Nevada 1983
Herbs from High Plains, Tertiary grasses and other 1969
HESS, H. H.: Appalachian peridotite belt: its significance in sequence of events in mountain building 1996
HESSE, C. J.: Texas fossil fishes..... 1971
High Plains, Tertiary grasses and other herbs from 1969
HINDS, N. E. A.: Pre-Cambrian igneous complexes and orogenies in western North America 1958
History of Coastal Plain, Heavy minerals and 1993
HOBBS, W. H.: Greenland as an American outpost 1996
HODGE, E. T.: Bonneville-Grand Coulee power and Alaskan minerals 2024
—: Cascade andesites of Oregon..... 1959
—: Glacial history of southeastern Washington 2024
—: Mineral resources of Northwest..... 2025
—: Structure and petrography of Oregon Cascades 2025
HOLLIDAY, SAMUEL: Ordovician trilobites of Nevada 1984
HORBERG, LELAND, *et al.*: Structural types and trends in central western Wyoming..... 1930
HORTON, R. E.: Hydro-physical approach to quantitative morphology of drainage basins 1996
HOSKINS, H. A., *et al.*: Origin and geochemistry of connate waters in West Virginia 1995
HOWARD, A. D.: Pediment gaps of Sacaton Mountains, Arizona 1930
HOWELL, B. F.: Cambrian *Skolithos* and *Planolites* at Reading, Pennsylvania..... 1972
—: Geological museum of future..... 1997
—: "*Scolithus verticalis*" Hall is *Monocraterion clintonense* (James)..... 1972
HUBBARD, G. D.: Illinoian glaciation in Killbuck Valley south of Millersburg, Ohio.. 1997
HURLEY, P. M., AND GOODMAN, CLARK: Investigation of helium retention in common rock minerals for purpose of age determination 1931
Hybridization and shearing in banded gneisses near Philadelphia 1989
Hydrology of Saint Croix, Virgin Islands.... 1992

Page

Hydrology of southeastern Virginia Coastal Plain 1992
Hydrometer method for size analysis, Pipette 1929
Hydro-physical approach to quantitative morphology of drainage basins 1996
Hydrothermal deposits in Specimen Mountain volcanics, Colorado 1951

Ice recession, Significance of hillside channels in Pleistocene 1933
Idaho, Geology of Coeur D'Alene mining district 2036
—, Orbicular rock from Buffalo Hump..... 1928
—, Origin of clastic dikes in Lewiston Basin 2027
—, Pleistocene history of Lewiston Basin... 2027
— batholith, Endomorphism of 2016
Igneous activity in New England, Paleozoic 1990
— and metamorphic rocks of Rumney quadrangle, New Hampshire 1936
— complexes in western North America..... 1958
— rock in Olympic Peninsula, Washington, New data on distribution of..... 2023
— rocks from Jamestown, Colorado, Spectroscopic distribution of minor elements in 1921
— — of Copple Crown-Merrymeeting Lake area of New Hampshire..... 1940
— — — Terlingua-Solitario region, Texas... 1539
— — — Winnipesaukee region of New Hampshire 2005
— structures, Ore deposit controlled by.... 1963
Illinoian glacial boundary in northeastern Ohio, New evidence for an..... 1337
— glaciation in Killbuck Valley south of Millersburg, Ohio 1997
Illinois, Elongate drift hills of southern.... 951
—, Glaciation of Grays Lake quadrangle 1329
—, Periglacial involutions in northeastern.. 1945
Immiscibility, Evidence of sulfide-silicate.. 2003
Improved laboratory procedures: Introduction to minerals and rocks..... 2042
Independence shale of Iowa..... 1978
Index of Paleozoic Pelmatozoa: Bibliographic and faunal..... 1967
— — Permian invertebrates, Bibliographic.. 1967
Indications of Cretaceous New Jersey shore lines 1992
Industrial limestones in Virginia..... 2039
— mineral production, Economic aspects of 2040
Influence of structure on ore deposits in Coeur D'Alene district 2029
INGERSON, EARL: Some features of origin of quartz veins at Grass Valley, California 1931
Instrumental search for meteorites, Preliminary report on..... 2040
Internal heat of earth..... 1948
Interpretation of cross section of Blue Ridge north of Balcony Falls, Virginia..... 1990
Intra-canyon lava flow of lower granite gorge, Grand Canyon..... 1956
Introduction to rocks and minerals: Improved laboratory procedures 2042
Investigation of helium retention in common rock minerals for purpose of age determination 1931
Involutions in northeastern Illinois..... 1945
Iowa, Independence shale of..... 1978
Iran Upper Cretaceous pelecypods of *Venericardia beaumonti* group from..... 1976
IRELAND, H. A.: New evidence for Illinoian glacial boundary in northeastern Ohio.. 1337
Iron meteorites, Structural history of..... 2040
IVES, R. L.: Rock glaciers in the Colorado Front Range 1271

Jade from Monterey County, California... 1941
JEFFORDS, R. M., AND MOORE, R. C.: Permian corals from North America..... 1974
JENKINS, O. P.: Strategic position of California in geology and mineral industry.. 2025

Page

JOHNSON, HELGI: Further observations on Lower Paleozoic sequence of western Newfoundland 1998
JOHNSON, M. E.: Composition and structure of Coastal Plain in New Jersey..... 1998
JOHNSTON, W. D., JR.: Gravity section across Sierra Nevada 1391
Joint patterns in highly folded and crystalline rocks of northern New Jersey Highlands and their relation to Appalachian orogeny 1919
Jointing in sedimentary rocks..... 1937
JONES, A. E.: Modoc lava surfaces..... 1959
June Lake district, California, Quaternary geology of 1939

Karst, Caliche 1938
KAY, G. M.: Taconic disturbance and associated events 1932
KEEN, A. M., AND BENTSON, HERDIS: Check list of California Tertiary marine Mollusca 1972
KEITH, ASHTON: Validity of four additional classes of arcuate structures..... 1998
KELLUM, L. B.: Paleogeographic studies of Mesozoic in northern Mexico..... 1932
Kentucky, Tuscaloosa formation of..... 1940
KEPPEL, DAVID: Concentric patterns in granites of Llano-Burnet region 971
KERR, P. F.: Tungsten-bearing manganese deposit at Golconda, Nevada.....1359, 2026
— AND LOMERSON, W. W.: Occurrence of pinite rock 1933
KESLER, T. L.: Genetic history of pegmatites and associated rocks of Carolina tin belt 1999
Keweenaw Point, New data on some problems of 1962
Key brachiopod faunas in Cambrian of Montana 1967
KEYES, CHARLES: Diversity of Eparchean interval over Cordillera..... 1960
—: Physiography of Great Basin Ranges... 1960
Killbuck Valley south of Millersburg, Ohio, Illinoian glaciation in 1997
Koolau basalt series, Oahu, Hawaii..... 1953
Korea, Relief regions of Tyosen..... 2002
KRUMBEIN, W. C.: Effects of abrasion on size, shape, and roundness of rock fragment. 1933
KRYNINE, P. D.: Appalachian orogeny and sedimentation 1999
Kyanite from Santa Catalina Island..... 1955

Laccolith, Bearpaw Mountains, Montana, Structure and petrology of Boxelder..... 1937
LADOO, R. B.: Economic aspects of industrial mineral production 2040
Lake Michigan, Dune form and wind direction along 1947
— —, Low and ball of eastern shore of..... 2039
— Missoula, Montana, Ripple marks (?) in glacial 2028
— Superior, New data on some problems of Keweenaw Point 1962
— — pre-Cambrian by accessory-mineral methods, Studies of..... 1429
Lamellae in Ajibik quartzite..... 1925
LANE, A. C.: Gravity versus "volatile transfer" differentiation and connate waters.. 2000
LA PAZ, LINCOLN: Preliminary report on an instrumental search for meteorites..... 2040
Larger physical features of Alaska..... 2032
Late Paleozoic history of central Oregon... 1935
— Quaternary changes of level in western and southern Newfoundland 1757
— Tertiary stratigraphy and paleontology of south-central Washington and adjacent Oregon 2018
Later Tertiary succession of life zones on southwest slope of Mount Diablo..... 1985

Page

LAUDERMILK, J. D., *et al.*: Treanorite, a new mineral from Crestmore, California..... 1965
Laurel migmatite, Origin of..... 1992
Lava flow of lower granite gorge, Grand Canyon 1956
— surfaces, Modoc 1959
Lebanon Mountains, Geological observations in 1951
LEET, L. D.: Physical frontiers in seismology 2000
Lehigh County, Pennsylvania, Martinsburg sequence in 2012
Lewiston Basin, Washington and Idaho, Origin of clastic dikes in..... 2027
— — of Washington and Idaho, Pleistocene history of 2027
LIBBEY, F. W.: Oregon's mineral industries and mineral resources 2026
Lima, Pennsylvania, Association of pyroxene granite and serpentine near..... 2002
Limestone, Study of Abrigo..... 1964
— produced by sun-cracking, Columnar... 1923
Limestones in Virginia, Industrial..... 2039
Liquid phases in system CO_2-H_2O-K_2O-SiO_2, Equilibrium between vapor and..... 1035
Livestock resources and problems, Alaskan.. 2036
Llano-Burnet region, Texas, Concentric patterns in granites of..... 971
Localities in Texas, New fossil..... 1977
LOCKE, AUGUSTUS, AND BILLINGSLEY, PAUL: Regional correlation of structural elements-problems: western United States.. 1955
Locomotor methods of earlier tetrapods, Tarsus and 1976
Logarithmic scale for rock diagrams..... 1950
LOMERSON, W. W., AND KERR, P. F.: Occurrence of pinite rock..... 1933
Long Beach, California, Barrier beach formation at 1957
LONGWELL, C. R.: Problems of orogeny..... 2001
LONSDALE, J. T.: Igneous rocks of Terlingua-Solitario region, Texas..... 1539
LORD, J. O.: Structural history of iron meteorites 2040
Losee gneiss in Pennsylvania..... 1994
LOUGEE, R. J.: Significance of hillside channels in Late Pleistocene ice recession... 1933
Louisiana, Quaternary history of..... 1199
— coastal region, Subsurface studies by petroleum geologists in..... 1951
— Gulf Coast, Exhibit of stratigraphy and structural forms of..... 1952
— -Texas Gulf Coast as a classic region in study of sedimentation..... 1949
LOVE, J. D.: Thrust faulting at southern end of Big Horn Mountains, Wyoming..... 1934
Low and ball of eastern shore of Lake Michigan 2039
Lower Cretaceous Rocky Mountain nonmarine microfossils 1974
— Permian Lueders formation of Baylor County, Texas, "Bone pocket" in..... 1975
Low-grade metamorphism of Covada sediments along Columbia River..... 2019
LUCKE, J. B.: Pre-Raritan River gravels in Raritan Valley, New Jersey..... 2001
Lueders formation of Baylor County, Texas, "Bone pocket" in Lower Permian..... 1975
LUGN, A. L.: Tertiary and Pleistocene sedimentation in relation to Pliocene-Pleistocene boundary in Great Plains..... 1934
LUPHER, R. L.: Origin of clastic dikes in Lewiston Basin, Washington and Idaho 2027
—: Pleistocene history of Lewiston Basin of Washington and Idaho..... 2027

MAC CLINTOCK, PAUL: Marine topography of Cape May formation 2002
—, AND TWENHOFEL, W. H.: Surface of Newfoundland 1665
— — —: Wisconsin glaciation of Newfoundland 1729

Page

MACKIN, J. H.: Glacial geology of Snoqualmie-Cedar area 2028
Magnesite, Structural features of Washington 2018
Magnetic investigations in Atlantic Coastal Plain 2013
— profile of North America, Trans-continental 1954
— survey of Wells Creek Basin, Tennessee.. 1953
Maine, Silurian strata of Aroostook County 1978
Major faulting in Triassic of New Jersey... 1994
Mammalian paleontology, Black Hawk Ranch Quarry fauna: value of large collections in 1985
Manganese deposit at Golconda, Nevada, Tungsten-bearing 1359, 2026
MANSFIELD, G. R.: Geology of phosphate deposits in United States..... 2040
Map of North America, Proposed glacial map 1926
Mapping the changing world: suggested improvements in maps..... 1990
Maps, Suggested improvements in..... 1990
Margarita Island, Venezuela, Pleistocene mollusks from 1975
Marine beds in North Dakota, Foraminiferal evidence for Midway (Paleocene) age of 1970
— fauna in Eastend formation of Saskatchewan, Canada, Discovery of a..... 1976
— Mollusca, Check list of California Tertiary 1972
— Pleistocene fossils from Newfoundland... 1781
— — mollusks from east coast of North America 2005
— topography of Cape May formation..... 2002
MARKS, J. G.: Eocene stellate orbitoidal Foraminifera from type Tejon formation, Grapevine Canyon, California..... 1984
MARSDEN, R. W., *et al.*: Studies of Lake Superior pre-Cambrian by accessory-mineral methods 1429
Martinsburg sequence in Lehigh County, Pennsylvania 2012
Maryland, Foraminife. of Miocene of..... 1993
—, Mollusks of Calvert and Choptank Miocene in 2006
Massanutten Mountain syncline in northern Virginia, Subordinate structures of..... 1994
Mastodon, New Pliocene..... 1659
Mathematical theory, Seismologist's difficulties with 2039
MATHEWS, A. A. L.: Complex structures of New River Basin..... 2002
—: Paleozoic faunas of New River Basin... 1973
Maui, Origin of Haleakala Crater..... 1948
MAXSON, J. H.: Colorado River system in Grand Canyon 1961
— AND CAMPBELL, IAN: Intra-canyon lava flow of lower granite gorge, Grand Canyon.. 1956
MCALLISTER, J. F.: Melanite-nepheline syenite from Panamint Range, California..... 1967
—: *Palaeocyclus porpita*, Silurian coral from Panamint Range, California..... 1984
MCCUNE, SHANNON: Relief regions of Tyosen (Korea) 2002
MCKELVEY, V. E., AND HELLMAN, N. N.: Pipette-hydrometer method for size analysis 1929
Measurement of terrestrial radioactivities... 1927
Measurements in parallel folds, Stratigraphic 1107
Mechanics of metamorphic orogeny..... 1964
MEHL, M. G., AND BRANSON, E. B.: New Ordovician conodont faunas..... 1968
MEIER, A. E.: Association of pyroxene granite and serpentine near Lima, Pennsylvania 2002
Melanite-nepheline syenite from Panamint Range, California 1961
MERRIAM, C. W., AND BERTHIAUME, S. A.: Late Paleozoic history of central Oregon 1935
MERRIAM, RICHARD: Southern California ring dike 1962
Merrymeeting Lake area, New Hampshire, Igneous rocks of..... 1940

Page

MERTIE, J. B., JR.: Stratigraphic measurements in parallel folds..... 1107
Mesozoic Andean geosyncline..... 1963
— in northern Mexico..... 1932
Metaconcretions of Thunder Lake, Ontario, Archean 1841
Metamorphic orogeny 1964
— rocks of Rumney quadrangle..... 1936
Metamorphism, Experiments in dynamic....1928
— of Covada sediments along Columbia River, Low-grade 2019
Metasomatic rocks, Criteria for distinguishing from orthomagmatic..... 2023
Meteor Crater, Odessa..... 1944
Meteorites, Preliminary report on an instrumental search for..... 2040
—, Structural history of iron..... 2040
Methods of geological subsurface studies by petroleum geologists in Texas-Louisiana coastal region 1951
Mexico, Cores from Gulf of..... 1943
—, Mesozoic in 1932
Michigan, Quartz lamellae in Ajibik quartzite 1925
Microfossils, Lower Cretaceous Rocky Mountain nonmarine 1974
Mictaw fauna of Gaspé, Correlation and significance of 1974
(Middle Eocene) of Reef Ridge, California, Foraminiferal faunule from Avenal sandstone 1982
Midway (Paleocene) age of Cannonball marine beds in North Dakota, Foraminiferal evidence for 1970
Migmatite, Origin of Laurel..... 1992
MILLER, A. K., *et al.*: Ozarkian and Canadian cephalopods: Part 1, Nautilicones..... 1979
Millersburg, Ohio, Illinoian glaciation in Killbuck Valley south of..... 1997
Mineral from Crestmore, California, A new 1965
— industries, Oregon's 2026
— industry, Strategic position of California in 2025
— production, Economic aspects of industrial 2040
— resources, Oregon's 2026
— — of Alaska 2032
— — — Northwest 2025
— waters, Geochemical data on Saratoga.... 2008
Minerals, Bonneville-Grand Coulee power and Alaskan 2024
—, Reflectance of opaque..... 2003
— and history of Coastal Plain, Heavy..... 1993
— — rocks, Introduction to: Improved laboratory procedures 2042
Mining district, Idaho, Geology of Coeur D'Alene 2036
Minnesota, Rock series in diabase sills at Duluth 1135
Mint Canyon, and Barstow formations, New evidence on faunal relations of Ricardo 1936
Miocene Equidae from San Antonio Mountains near Tonopah, Nevada, Upper... 1983
— in Maryland, Mollusks of Calvert and Choptank 2006
— of Maryland, Foraminifera of..... 1993
— — Palos Verdes Hills, California, Fossil fish from 1982
— sessile barnacles from Southern California 1987
Mississippi delta, Cores from Gulf of Mexico off 1943
— —, Organic content of cores from Gulf of Mexico off..... 1920
— River, Pleistocene terraces of..... 2041
Mississippian, of central Montana, Ostracoda from Otter formation..... 1977
Modoc lava surfaces..... 1959
Mollusca, Check list of California Tertiary marine 1972
Mollusks from east coast of North America, Marine Pleistocene 2005
— — Margarita Island, Venezuela, Pleistocene 1975

Page

Mollusks of Calvert and Choptank Miocene in Maryland ... 2006
Monocraterion clintonense (James), "*Scolithus verticalis*" Hall is ... 1972
Montana, Key brachiopod faunas in Cambrian of ... 1967
—, Ostracoda from Otter formation, Mississippian, of central ... 1977
—, Ripple marks (?) in glacial Lake Missoula ... 2028
—, Structure and petrology of Boxelder laccolith, Bearpaw Mountains ... 1937
Monterey County, California, Nephrite jade from ... 1941
— quadrangle, Topography of ... 2009
Moodey, M. W., and Bassler, R. S.: Bibliographic and faunal index of Paleozoic Pelmatozoa ... 1967
Moon as a source of tektites ... 1936
Moore, R. C.: Pennsylvanian bellerophontid gastropods ... 1973
— and Ewers, J. D.: Growth stages of *Symbathocrinus* ... 1973
— — Jeffords, R. M.: Permian corals from North America ... 1974
Morey, G. W., and Fleischer, M.: Equilibrium between vapor and liquid phases in system CO_2-H_2O-K_2O-SiO_2 ... 1035
Morphology of drainage basins, Hydrophysical approach to quantitative ... 1936
Motions in vicinity of a fault slip ... 1929
Mount Diablo, Later Tertiary succession of life zones on southwest slope of ... 1985
Mountain building, Significance of Appalachian peridotite belt in sequence of events in ... 1996
Mountains in Gulf of Alaska, Submarine ... 1935
Moyd, Louis: Evidence of sulfide-silicate immiscibility ... 2003
Muck-silt deposits at Fairbanks, Alaska, Origin of ... 1295
Murray, H. W.: Submarine mountains in Gulf of Alaska ... 1935
Museum of future, Geological ... 1997

National defense, Course on geography of ... 2010
— —, Geographical material in libraries of U. S. with especial reference to ... 2004
Nautilicones, Ozarkian and Canadian cephalopods: Part 1 ... 1979
(Nautiloidea), Superfamily Discosoroidea ... 1969
Nelson, V. N., *et al.*: Structural types and trends in central western Wyoming ... 1930
Nepheline-melanite syenite from Panamint Range ... 1961
Nephrite jade from Monterey County, California ... 1941
Neumann, Frank, and Heck, N. H.: Earth motions in vicinity of a fault slip ... 1929
Nevada, Ordovician trilobites of ... 1984
—, Stratigraphy and structure of southern Ruby Mountains ... 1945
—, Tungsten-bearing manganese deposit at Golconda ... 1359, 2026
—, Upper Miocene Equidae from San Antonio Mountains near Tonopah ... 1983
—, Welded tuff resembling vitrophyre and pitchstone at Bare Mountain ... 1957
New data on distribution of igneous rock in Olympic Peninsula, Washington ... 2023
— — — some problems of Keweenaw Point, Lake Superior ... 1962
— England, Granitization in western ... 1989
— —, Paleozoic igneous activity in ... 1990
— evidence for Illinoian glacial boundary in northeastern Ohio ... 1337
— — on faunal relations of Ricardo, Mint Canyon, and Barstow formations ... 1986
— fossil localities in Texas ... 1977
— genus of Gastropoda, probable ancestor of Grangerellidae from Upper Cretaceous of Alberta ... 1976

Page

New Hampshire, Glacial deposits of Canaan area ... 1924
— —, Igneous and metamorphic rocks of Rumney quadrangle ... 1938
— —, — rocks of Copple Crown-Merrymeeting Lake area ... 1940
— —, — — — Winnipesaukee region of ... 2005
— —, Perthite from central ... 1946
— —, Petrology of Pawtuckaway Mountains 1942
— Jersey, Composition and structure of Coastal Plain in ... 1988
— —, Geophysical investigations in emerged and submerged Atlantic Coastal Plain of 1821
— —, Major faulting in Triassic of ... 1994
— —, Pre-Raritan River gravels in Raritan Valley ... 2001
— — and Alabama, Correlation of lower Eocene formations of ... 2009
— — Highlands, Joint patterns in highly folded and crystalline rocks of ... 1919
— — shore lines, Indications of Cretaceous .. 1992
— Mexico, Pennsylvanian Scaphopoda and Cephalopoda from ... 1979
— Ordovician conodont faunas ... 1968
— Pliocene mastodon ... 1659
— reconstruction of skeleton of *Eusthenopteron* and its bearing on evolution of paired fins ... 1971
— River Basin, Complex structures of ... 2002
— — —, Paleozoic faunas of ... 1973
— York, Phase petrology in Cortland complex ... 1944
Newfoundland, Further observations on Lower Paleozoic sequence of western ... 1998
—, Late Quaternary changes of level in western and southern ... 1757
—, Marine Pleistocene fossils from ... 1781
—, Surface of ... 1665
—, Wisconsin glaciation of ... 1729
Newport Bay area, southern California, Pleistocene history of ... 1981
Nininger, H. N.: Moon as a source of tektites ... 1936
Nitrate deposits of Tarapacá, Chile ... 1941
Noble, L. F.: Structural features of Virgin Spring area, Death Valley, California ... 1936
Nonmarine microfossils, Lower Cretaceous Rocky Mountain ... 1974
North America, Marine Pleistocene mollusks from east coast of ... 2005
— —, Permian corals from ... 1974
— —, Pre-Cambrian igneous complexes and orogenies in ... 1958
— —, Proposed glacial map of ... 1926
— —, Trans-continental gravitational and magnetic profile of ... 1954
— Atlantic, Foraminifera of submarine cores from ... 1975
— Carolina, Triassic of Anson County ... 1920
— Dakota, Foraminiferal evidence for Midway (Paleocene) age of Cannonball marine beds in ... 1970
Northrop, S. A.: Correlation and significance of Mictaw fauna of Gaspé ... 1974
Northwest, Distribution of historic earthquakes in Pacific ... 2034
—, Geological history of Tertiary in Pacific 2035
—, Ground-water problems in Pacific ... 2029
—, Mineral resources of ... 2025
— geography, Bases of ... 2021

Oahu, Hawaii, Koolau basalt series ... 1953
Occurrence of pinite rock ... 1933
Ocean, Radio-elements in water and sediments of ... 2010
Odessa meteor crater ... 1944
Ohio, Illinoian glaciation in Killbuck Valley south of Millersburg ... 1997
—, New evidence for an Illinoian glacial boundary in northeastern ... 1337
Okanogan Valley, Washington, Geology of .. 2035

Page

Oligocene coral faunas of Washington, Eocene and 1983
Olympic Peninsula, Washington, Browns Point formation of 2022
— —, —, Distribution of igneous rock in.... 2023
Ontario, Archean metaconcretions of Thunder Lake 1841
Opaque minerals, Reflectance of..... 2003
Orange County, California, Geology of San Joaquin Hills 1956
Orbicular rock from Buffalo Hump, Idaho... 1928
Orbitoidal Foraminifera from type Tejon formation, Grapevine Canyon, California, Eocene stellate 1984
Ordovician conodont faunas, New..... 1963
— trilobites of Nevada..... 1984
Ore deposit controlled by primary igneous structures 1963
— deposits in Coeur d'Alene district, Influence of structure on..... 2029
— -bearing pipes in Tarryall Range, Colorado 1923
Oregon, Cascade andesites of..... 1959
—, Chromite in 2015
—, Economic geology of California and southern 2017
—, Geology of Portland area..... 2034
—, Late Paleozoic history of..... 1935
—, — Tertiary stratigraphy and paleontology of south-central Washington and adjacent 2018
—, Tectonics of Northern Wallowa Mountains 2015
— Cascades, Structure and petrography of 2025
— quicksilver deposits, Regional control of.. 2033
— shore line 2033
Oregon's mineral industries and mineral resources 2026
Organic content of cores from Gulf of Mexico off Mississippi Delta 1920
Orientation in sediments, Petrofabric determination of quartz grain..... 1941
Origin and distribution of tektites..... 1919
— — geochemistry of connate waters in West Virginia 1995
— of caliche 1939
— — clastic dikes in Lewiston Basin, Washington and Idaho 2027
— — Haleakala Crater, Maui, Hawaii..... 1948
— — Laurel migmatite..... 1992
— — muck-silt deposits at Fairbanks, Alaska 1295
— — nitrate deposits of Tarapacá, Chile.... 1941
— — quartz veins at Grass Valley, California 1931
Oriskany-Helderberg (Upper) relations in West Virginia..... 2012
Orogenies in western North America..... 1958
Orogeny, Joint patterns in highly folded and crystalline rocks and their relation to Appalachian 1919
—, Mechanics of metamorphic..... 1964
—, Problems of 2001
— and sedimentation, Appalachian 1999
Orthomagmatic rocks, Criteria for distinguishing from metasomatic 2023
Ostracoda from Otter formation, Mississippian, of central Montana..... 1977
Otter formation, Mississippian, of central Montana, Ostracoda from 1977
Overthrust, Cheyenne Mountain..... 1942
—, Further evidence of Reading..... 2007
Ozarkian and Canadian cephalopods: Part 1, Nautilicones 1979

Pacific Northwest, Distribution of historic earthquakes in 2034
— —, Geological history of Tertiary in..... 2035
— —, Ground-water problems in..... 2029
Page, L. R.: Igneous and metamorphic rocks of the Rumney quadrangle, New Hampshire 1936

Page

Palaeocyclus porpita, Silurian coral from Panamint Range, California..... 1984
(Paleocene) age of Cannonball marine beds in North Dakota, Foraminiferal evidence for Midway 1970
Paleoecological significance, Pyrite faunas of Washita and Eagle Ford groups of Texas Cretaceous and 1977
Paleogeographic studies of Mesozoic in northern Mexico 1932
Paleogeography of Arizona..... 1950
Paleontological evidence regarding Pliocene-Pleistocene boundary in Great Plains.... 1943
Paleontology, Black Hawk Ranch Quarry fauna: value of large collections in mammalian 1985
— of south-central Washington and adjacent Oregon, Late Tertiary stratigraphy and 2018
Paleozoic faunas of New River Basin..... 1973
— history of central Oregon..... 1935
— igneous activity in New England..... 1990
— (Lower) sequence of western Newfoundland, Further observations on..... 1998
— paleogeography of Arizona..... 1950
— Pelmatozoa, Bibliographic and faunal index of 1967
— sections in Texas, Correlation of Early.... 1921
Palisade diabase, Differentiation of..... 1059
Palos Verdes Hills, California, Fossil fish from Miocene of..... 1982
Panama Canal, Geography and defense of... 1991
Panamint Range, California, *Palaeocyclus porpita*, Silurian coral from..... 1984
— —, Melanite-nepheline syenite from..... 1961
Pardee, J. T.: Ripple marks (?) in glacial Lake Missoula, Montana..... 2028
Parker, J. M., III: Regional systematic jointing in slightly deformed sedimentary rocks 1937
Parrish, William: Reflectance of opaque minerals 2003
Pawtuckaway Mountains, New Hampshire, Petrology of 1942
Peck, R. E.: Lower Cretaceous Rocky Mountain nonmarine microfossils..... 1974
Pecora, W. T.: Structure and petrology of Boxelder laccolith, Bearpaw Mountains, Montana 1937
Pecten sanctaecruzensis in California, Stratigraphic occurrence of..... 1983
Pediment gaps of Sacaton Mountains, Arizona 1930
Pegau, A. A.: Distribution of Petersburg granite in southeastern Piedmont, Virginia 2004
Pegmatites and associated rocks of Carolina tin belt 1999
Pelecypods of *Venericardia beaumonti* group from Iran, Upper Cretaceous 1976
Pelmatozoa, Bibliographic and faunal index of Paleozoic 1967
Pennsylvania, Association of pyroxene granite and serpentine near Lima..... 2002
—, Cambrian *Skolithos* and *Planolites* at Reading 1972
—, Hybridization and shearing in banded gneisses near Philadelphia..... 1989
—, Martinsburg sequence in Lehigh County 2012
—, Pochuck, Byram, and Losee gneisses in.. 1994
—, Spitzenberg conglomerate as a Triassic outlier in 2011
—, Triassic dikes of basaltic glass at Safe Harbor 2009
Pennsylvanian bellerophontid gastropods.... 1973
— Scaphopoda and Cephalopoda from New Mexico 1979
Peridotite belt, Appalachian..... 1998
Periglacial involutions in northeastern Illinois 1945

Page

Permian corals from North America..... 1974
— Lueders formation of Baylor County, Texas, "Bone pocket" in Lower..... 1975
Perthite from central New Hampshire..... 1946
Petersburg granite in southeastern Piedmont, Virginia, Distribution of..... 2004
Petrofabric analysis of dolomite..... 1926
— determination of quartz grain orientation in sediments 1941
— notes on quartz lamellae in Ajibik quartzite, Michigan..... 1925
Petrography of the Oregon Cascades..... 2025
Petroleum geologists, Subsurface studies by 1951
Petrology in Cortland complex..... 1944
— of Boxelder laccolith, Bearpaw Mountains, Montana, Structure and 1937
— — Pawtuckaway Mountains, New Hampshire 1942
PETTIJOHN, F. J.: Archean metaconcretions of Thunder Lake, Ontario..... 1841
—: — sedimentation 1938
Phase petrology in Cortland complex, New York 1944
Phases in system CO_2-H_2O-K_2O-SiO_2, Equilibrium between vapor and liquid..... 1035
Philadelphia, Hybridization and shearing in banded gneisses near..... 1989
— area, Granitic rocks of..... 2004
PHLEGER, F. B, Jr.: Foraminifera of submarine cores from North Atlantic..... 1975
Phosphate deposits in United States, Geology of 2040
Physical approach to quantitative morphology of drainage basins, Hydro-.... 1996
— features of Alaska..... 2032
— frontiers in seismology..... 2000
Physiographic setting of nitrate deposits of Tarapacá, Chile: Its bearing on problem of origin..... 1941
— types, Submarine 2007
Physiography of Great Basin Ranges..... 1960
Piedmont, Virginia, Distribution of Petersburg granite in southeastern..... 2004
Piedmontite and kyanite from Franciscan of Santa Catalina Island..... 1955
Pinite rock, Occurrence of..... 1933
PIPER, A. M.: Ground-water problems in Pacific Northwest 2029
Pipes in Tarryall Range, Colorado, Ore-bearing 1923
Pipette-hydrometer method for size analysis 1929
Pitchstone, Tuff resembling..... 1957
Planolites at Reading, Pennsylvania, Cambrian *Skolithos* and 1972
Plateau basalts of eastern Washington, Relation to andesitic rocks of Cascade Mountains 2034
PLATT, E. T.: Geographical materials in libraries of U. S. with especial reference to national defense..... 2004
PLATTS, J. B.: Influence of structure on ore deposits in Coeur D'Alene district..... 2029
Pleistocene artifacts and associated fossils from Bee County, Texas..... 1627
— boundary in Great Plains..... 1934
— — — — —, Paleontological evidence regarding 1943
— fossils at Rincon Creek, Santa Barbara County, California, Pliocene and..... 1981
— — from Newfoundland, Marine..... 1781
— history of Lewiston Basin of Washington and Idaho 2027
— — — Newport Bay area, southern California 1981
— ice recession, Significance of hillside channels in 1933
— mollusks from east coast of North America, Marine 2005
— — — Margarita Island, Venezuela..... 1975
— sedimentation 1934

Page

Pleistocene stone images from Texas..... 1944
— terraces of Mississippi River..... 2041
Pliocene and Pleistocene fossils at Rincon Creek, Santa Barbara County, California 1981
— Equidae of Texas Gulf Coastal Plain..... 1970
— formations in California..... 1956
— mastodon, New 1659
— -Pleistocene boundary in Great Plains.... 1934
— — — — — —, Paleontological evidence regarding 1943
Pochuck, Byram, and Losee gneisses in Pennsylvania 1994
Portland, Oregon, area, Geology of..... 2034
Postaxial borders in paired appendages of rhipidist fishes and their bearing on origin of tetrapod limbs, Relations of preaxial and 1971
POSTEL, A. W.: Granitic rocks of Philadelphia area 2004
Power and Alaskan minerals, Bonneville-Grand Coulee 2024
POWERS, W. E., and EKBLAW, G. E.: Glaciation of Grays Lake, Illinois, Quadrangle 1329
Prairie, Trend of changes in Late Tertiary.. 1925
Preaxial and postaxial borders in paired appendages of rhipidist fishes and their bearing on origin of tetrapod limbs, Relations of 1971
Pre-Cambrian by accessory-mineral methods, Studies of Lake Superior..... 1429
— igneous complexes and orogenies in western North America 1958
Preliminary report on an instrumental search for meteorites 2040
Pre-Raritan River gravels in Raritan Valley, New Jersey 2001
PRICE, W. A.: Caliche karst..... 1938
—: Origin of caliche..... 1939
Problems of American defense, Strategic.... 2006
— — coal distribution and transportation in war time 2011
— — orogeny 2001
Profile of North America and its relation to geologic structure, Trans-continental gravitational and magnetic..... 1954
Progress in study of *Archimedes*..... 1968
Proposed glacial map of North America.... 1926
PROUTY, C. E., and COOPER, B. N.: Chazyan and Black River stratigraphy in Tazewell County, Virginia 1924
Public lands in Alaska, Utilization of..... 2030
Puget Sound earthquake of November 12, 1939 2017
PUTNAM, W. C.: Quaternary geology of June Lake district, California..... 1939
Pyrite faunas of Washita and Eagle Ford groups of Texas Cretaceous and paleoecological significance 1977
Pyroxene granite and serpentine near Lima, Pennsylvania, Association of..... 2002

Quartz grain orientation, Petrofabric determination of 1941
— lamellae in Ajibik quartzite, Petrofabric notes on 1925
— veins, Origin of..... 1931
Quartzite, Michigan, Petrofabric notes on quartz lamellae in Ajibik..... 1925
Quaternary, Changes of level in western and southern Newfoundland, Late..... 1757
— geology of June Lake district, California 1939
— history of Louisiana..... 1199
Quicksilver deposits, Regional control of Oregon 2033
— — of Coso Hot Springs area..... 1965
QUINN, ALONZO: Igneous rocks of Copple Crown-Merrymeeting Lake area of New Hampshire 1940
—: — — — Winnipesaukee region of New Hampshire 2005

Page

Radioactivities, Measurement of terrestrial.. 1927
Radio-elements in water and sediments of ocean 2010
Raritan Valley, New Jersey, Pre-Raritan River gravels in..... 2001
RAVEN, H. C., and GREGORY, W. K.: Relations of preaxial and postaxial borders in paired appendages of rhipidist fishes and their bearing on origin of tetrapod limbs 1971
RAY, L. L.: Glacial chronology of Southern Rocky Mountains 1851
READ, W. F.: "Bone pocket" in Lower Permian Lueders formation of Baylor County, Texas 1975
Reading, Pennsylvania, Cambrian *Skolithos* and *Planolites* at 1972
— overthrust, Further evidence of..... 2007
Recent recession of Dinwoody Glaciers, Wind River Mountains, Wyoming..... 1924
Reconstruction of skeleton of *Eusthenopteron* and its bearing on evolution of paired fins, New..... 1971
Recrystallization, Experimental flow of rocks under conditions favoring..... 1001
Reef Ridge, California, Foraminiferal faunule from Avenal sandstone (Middle Eocene) of..... 1982
Reflectance of opaque minerals..... 2003
Regional approach to economic planning in Alaska 2017
— control of Oregon quicksilver deposits.. 2033
— correlation of structural elements-problems: western United States..... 1955
— systematic jointing in slightly deformed sedimentary rocks..... 1937
Relation of Plateau basalts of eastern Washington to certain andesitic rocks of Cascade Mountains..... 2034
— — Tuscaloosa formation of western Kentucky to a pre-existing weathered terrain 1940
Relations of preaxial and postaxial borders in paired appendages of rhipidist fishes and their bearing on origin of tetrapod limbs 1971
Relief regions of Tyosen (Korea)..... 2002
Resources, Oregon's mineral industries and mineral 2026
—, Political control of nation's defense..... 2011
— and problems, Alaskan livestock..... 2036
— of Alaska, Mineral..... 2032
— — Northwest, Mineral..... 2025
Results of restudy of mollusks of Calvert and Choptank Miocene in Maryland.. 2006
Rhipidist fishes and their bearing on origin of tetrapod limbs, Relations of preaxial and postaxial borders in paired appendages of 1971
RHOADES, R. F.: Relation of Tuscaloosa formation of western Kentucky to a pre-existing weathered terrain..... 1940
Ricardo, Mint Canyon, and Barstow formations, New evidence on faunal relations of 1986
RICH, J. L.: Physiographic setting of nitrate deposits of Tarapacá, Chile: Its bearing on problem of origin..... 1941
RICHARDS, H. G.: Marine Pleistocene fossils from Newfoundland 1781
—: — — mollusks from east coast of North America 2005
—: Pleistocene mollusks from Margarita Island, Venezuela 1975
RICHEY, K. A.: Black Hawk Ranch Quarry fauna: value of large collections in mammalian paleontology 1985
—: Later Tertiary succession of life zones on southwest slope of Mount Diablo..... 1985
—: New evidence on faunal relations of Ricardo, Mint Canyon, and Barstow formations 1986

Page

RICHTER, C. F., and GUTENBERG, BENO: Seismicity of earth..... 1958
RIGGLEMAN, J. R.: Utilization of public lands in Alaska 2030
RILEY, L. B., and BUTLER, R. D.: Ore-bearing pipes in Tarryall Range, Colorado.. 1923
Rincon Creek, Santa Barbara County, California, Pliocene and Pleistocene fossils at 1981
Ring dike, Southern California..... 1961
Ripple marks (?) in glacial Lake Missoula, Montana 2028
RIST, R. L.: Stratigraphic study of *Aucella*-bearing beds of California Coast Ranges 1986
ROBERTS, ELLIS: New data on some problems of Keweenaw Point, Lake Superior..... 1961
ROBERTSON, PERCIVAL: Some Pleistocene terraces of Mississippi River..... 2041
Rock, Occurrence of pinite..... 1933
— diagrams, Logarithmic scale for..... 1950
— fragment, Effects of abrasion on..... 1933
— from Buffalo Hump, Orbicular..... 1928
— glaciers in Colorado Front Range..... 1271
— in Olympic Peninsula, Washington, Distribution of igneous..... 2023
— minerals, Helium retention in..... 1931
— series in diabase sills at Duluth, Minnesota 1135
— weathering, Crystallization of salt as a factor in..... 1956
ROCKIE, W. A.: Alaska's agricultural future 2030
Rocks, Criteria for distinguishing orthomagmatic from metasomatic..... 2023
—, Jointing in sedimentary..... 1937
— and minerals, Introduction to: Improved laboratory procedures..... 2042
— of Cascade Mountains, Relation of Plateau basalts of eastern Washington to andesitic 2034
— — Copple Crown-Merrymeeting Lake area, New Hampshire..... 1940
— — Philadelphia area, Granitic..... 2004
— — Rumney quadrangle, Metamorphic.... 1936
— — Twin Sisters Mountains, Washington, Ultrabasic 2019
— — Winnipesaukee region of New Hampshire, Igneous 2005
— under conditions favoring recrystallization, Experimental flow of..... 1001
Rocky Mountain nonmarine microfossils, Lower Cretaceous 1974
ROGERS, A. F.: Nephrite jade from Monterey County, California..... 1941
ROSINSKI, HERBERT: Strategic problems of American defense..... 2006
ROSS, R. J., Jr., and FOX, S. K., Jr.: Foraminiferal evidence for Midway (Paleocene) age of Cannonball marine beds in North Dakota 1970
ROTHWELL, W. T., Jr.: Miocene sessile barnacles from Southern California..... 1987
ROUSE, J. T.: Structural and volcanic problems in Southern Absaroka Mountains, Wyoming 1413
ROWLAND, R. A.: Petrofabric determination of quartz grain orientation in sediments 1941
ROY, C. J.: Cheyenne Mountain overthrust, Colorado 1942
—, and FREEDMAN, JACOB: Petrology of Pawtuckaway Mountains, New Hampshire.. 1942
Ruby Mountains, Stratigraphy and structure of 1945
Rumney quadrangle, Metamorphic rocks of 1936
RUSSELL, L. S.: Discovery of a marine fauna in Eastend formation of Saskatchewan, Canada 1976
—: New genus of Gastropoda, probable ancestor of Grangerellidae from Upper Cretaceous of Alberta..... 1976
RUSSELL, R. D.: Cores from Gulf of Mexico off Mississippi delta..... 1943
RUSSELL, R. J.: Quaternary history of Louisiana 1199

Page

RUTSCH, R. F., and SCHENCK, H. G.: Upper Cretaceous pelecypods of *Venericardia beaumonti* group from Iran..... 1976

Sacaton Mountains, Pediment gaps of..... 1930
Safe Harbor, Pennsylvania, Triassic dikes of basaltic glass at..... 2009
Saint Croix, Virgin Islands, Geology and hydrology of 1992
Salmon fisheries of Alaska..... 2020
Salt as a factor in rock weathering..... 1956
— Lake City region, Epochs of volcanism in 2031
San Antonio Mountains near Tonopah, Nevada, Upper Miocene Equidae from 1983
— Joaquin Hills, California, Geology of.... 1956
— — Valley, Subsurface structure of..... 1957
SANDBERG, A. E., and SCHWARTZ, G. M.: Rock series in diabase sills at Duluth, Minnesota 1135
Sands of Guatemala, Central America, Black beach 1921
— on Gulf Coast of Texas, Source of beach 1922
Sandstone (Middle Eocene) of Reef Ridge, California, Foraminiferal faunule from Avenal 1982
Santa Barbara County, California, Pliocene and Pleistocene fossils at Rincon Creek 1981
— Catalina Island, Piedmontite and kyanite from 1955
— Monica Mountains, California, Upper Miocene fish from northern rim of.... 1982
Saratoga mineral waters, Geochemical data on 2008
Saskatchewan, Canada, Discovery of a marine fauna in Eastend formation of.... 1976
Scabland, Flint's fill hypothesis of origin of 2016
Scaphopoda and Cephalopoda from New Mexico, Pennsylvanian..... 1979
SCHAEFFER, BOBB: Tarsus and locomotor methods of earlier tetrapods..... 1976
SCHENCK, H. G., and RUTSCH, R. F.: Upper Cretaceous pelecypods of *Venericardia beaumonti* group from Iran..... 1976
SCHNEIDER, HYRUM: Epochs of volcanism in Salt Lake City region..... 2031
SCHOONOVER, L. M.: Results of restudy of mollusks of Calvert and Choptank Miocene in Maryland..... 2006
SCHULTZ, C. B., and STOUT, T. M.: Paleontological evidence regarding Pliocene-Pleistocene boundary in Great Plains.. 1943
SCHWARTZ, G. M., and SANDBERG, A. E.: Rock series in diabase sills at Duluth, Minnesota 1135
"Scolithus verticalis" Hall is *Monocraterion clintonense* (James)..... 1972
SCOTT, GAYLE: Cretaceous-Tertiary relationships in Coastal Plains area of Texas.. 2006
—: Pyrite faunas of Washita and Eagle Ford groups of Texas Cretaceous and paleoecological significance..... 1977
SCOTT, H. W.: Ostracoda from Otter formation, Mississippian, of central Montana 1977
SEAGER, G. F.: Geology of Shasta copper belt 2031
Section across Commercial Quarry, Crestmore, California 1965
Sedimentary rocks, Jointing in..... 1937
Sedimentation, Appalachian orogeny and.... 1999
—, Archean 1938
—, Louisiana-Texas Gulf Coast as a classic region in study of..... 1949
— in central Cordilleran region, Cambrian 2021
— — Gulf Coast Eocene..... 1949
Sediments, Andalusite in Californian Eocene 1919
—, Petrofabric determination of quartz grain orientation in..... 1941
— of ocean, Radio-elements in water and.. 2010
Seismicity of earth..... 1958
Seismologist's difficulties with some mathematical theory or lack of it..... 2039
Seismology, Physical frontiers in..... 2000

Page

SELLARDS, E. H.: New fossil localities in Texas 1977
—: — Pliocene mastodon..... 1659
—: Odessa meteor crater..... 1944
—: Pleistocene artifacts and associated fossils from Bee County, Texas..... 1627
—: — stone images from Texas..... 1944
Serpentine near Lima, Pennsylvania, Association of pyroxene granite and..... 2002
Sessile barnacles from Southern California, Miocene 1987
Shale of Iowa, Independence..... 1978
SHAND, S. J.: Phase petrology in Cortland complex, New York..... 1944
SHARP, R. P.: Ep-Archean and Ep-Algonkian erosion surfaces, Grand Canyon, Arizona 1235
—: Periglacial involutions in northeastern Illinois 1945
—: Stratigraphy and structure of southern Ruby Mountains, Nevada 1945
Shasta copper belt, Geology of..... 2031
Shearing in banded gneisses near Philadelphia, Hybridization and..... 1989
Shore line, Oregon..... 2033
— lines, Indications of Cretaceous New Jersey 1992
Sierra Nevada, Gravity section across..... 1391
Significance of Appalachian peridotite belt in sequence of events in mountain building 1996
— — hillside channels in Late Pleistocene ice recession 1933
Silicate-sulfide immiscibility, Evidence of.. 2003
Sills at Duluth, Minnesota, Rock series in diabase 1135
Silurian coral, from Panamint Range, California, *Palaeocyclus porpita*..... 1984
— of central Appalachians..... 2008
— strata of Aroostook County, Maine..... 1978
Skeleton of *Eusthenopteron* and its bearing on evolution of paired fins, New reconstruction of..... 1971
Skolithos and *Planolites* at Reading, Pennsylvania, Cambrian 1972
SLICHTER, L. B.: Internal heat of earth.... 1946
SMITH, ALEXANDER: Ore deposit controlled by primary igneous structures..... 1963
SMITH, A. P.: Perthite from central New Hampshire 1946
SMITH, H. T. U.: Dune form and wind direction along southern shore of Lake Michigan 1947
SMITH, PAUL A.: Submarine physiographic types 2007
SMITH, P. S.: Larger physical features of Alaska 2032
—: Mineral resources of Alaska..... 2032
—: Stratigraphy of Alaska..... 2033
SMITH, W. D.: Oregon shore line..... 2033
Snoqualmie-Cedar area, Glacial geology of.. 2028
Soft anatomy of *Bothriolepis canadensis*.... 1968
Soils, Bomb craters in..... 1922
Solids, "Flow" in stressed..... 1023
Solitario-Terlingua region, Texas, Igneous rocks of 1539
Some features of origin of quartz veins at Grass Valley, California..... 1931
Source of beach sands on Gulf Coast of Texas 1922
South America, Cretaceous-Tertiary relationships in northern..... 1995
Southern Absaroka Mountains, Wyoming, Structural and volcanic problems in.... 1413
— California, Miocene sessile barnacles from 1987
— — ring dike..... 1962
— Rocky Mountains, Glacial chronology of 1851
Specimen Mountain volcanics, Hydrothermal deposits in..... 1951
Spectroscopic distribution of minor elements in igneous rocks from Jamestown, Colorado 1921

Page

SPIEKER, E. M., and BILLINGS, M. P.: Glaciation in Wasatch Plateau, Utah..... 1173
Spitzenberg conglomerate as a Triassic outlier in Pennsylvania..... 2011
STAINBROOK, M. A.: Independence shale of Iowa 1973
STAPLES, L. W.: Regional control of Oregon quicksilver deposits 2033
Staunton quadrangle, Topography of..... 2009
STEARNS, H. T.: Four-phase volcanism in Hawaii 1947
—: Geologic history of Guam..... 1948
—: Origin of Haleakala Crater, Maui, Hawaii 1948
Stellate orbitoidal Foraminifera from type Tejon formation, Grapevine Canyon, California, Eocene 1984
STENZEL, H. B.: Sedimentation in Gulf Coast Eocene 1949
Stone images from Texas, Pleistocene..... 1944
STORM, L. W.: Louisiana-Texas Gulf Coast as a classic region in study of sedimentation 1949
STOSE, A. J., and STOSE, G. W.: Further evidence of Reading overthrust..... 2007
STOSE, G. W., and STOSE, A. J.: Further evidence of Reading overthrust..... 2007
STOUT, T. M., and SCHULTZ, C. B.: Paleontological evidence regarding Pliocene-Pleistocene boundary in Great Plains... 1943
STOYANOW, ALEXANDER: Paleozoic paleogeography of Arizona..... 1950
Strata of Aroostook County, Maine, Silurian 1978
Strategic position of California in geology and mineral industry..... 2025
— problems of American defense..... 2006
Stratigraphic measurements in parallel folds 1107
— occurrence of *Pecten sanctaecruzensis* in California 1983
— relations of Willamette Valley fill..... 2016
— study of *Aucella*-bearing beds of California Coast Ranges..... 1986
— terminology, Time and..... 1397
Stratigraphy and paleontology of south-central Washington and adjacent Oregon, Late Tertiary 2018
— — structure of southern Ruby Mountains, Nevada 1945
— in Tazewell County, Virginia, Chazyan and Black River..... 1924
— of Alaska 2033
— — Texas-Louisiana Gulf Coast, Exhibition of 1952
Stream terraces in Texas and their relation to formations of Gulf Coastal Plain.... 1952
Stressed solids, "Flow" in 1023
STROCK, L. W.: Geochemical data on Saratoga mineral waters..... 2008
Structural and volcanic problems in Southern Absaroka Mountains, Wyoming..... 1413
— elements-problems, Correlation of..... 1955
— features of Virgin Spring area, Death Valley, California..... 1936
— — — Washington magnesite 2018
— forms of Texas-Louisiana Gulf Coast, Exhibition of 1952
— history of iron meteorites..... 2040
— problems of east border of Colville batholith 2019
— types and trends in central western Wyoming 1930
Structure, Trans-continental profile of North America and its relation to geologic.... 1954
— and petrography of Oregon Cascades.... 2025
— — petrology of Boxelder laccolith, Bearpaw Mountains, Montana..... 1937
— as gigantic disperse phase of emulsion, Ellipsoidal 2022
— of Coastal Plain in New Jersey, Composition and 1993
— — San Joaquin Valley, California..... 1957
— — southern Ruby Mountains..... 1945

Page

Structure on ore deposits in Coeur d'Alene district, Influence of..... 2029
Structures, Validity of four additional classes of arcuate 1998
— of Massanutten Mountain syncline in northern Virginia, Subordinate..... 1994
— — New River Basin..... 2002
Studies of Lake Superior pre-Cambrian by accessory-mineral methods..... 1429
Study of Abrigo limestone..... 1964
STURDEVANT, R., and COOPER, J. C.: Pliocene and Pleistocene fossils at Rincon Creek, Santa Barbara County, California..... 1981
Submarine cores from North Atlantic, Foraminifera of 1975
— mountains in Gulf of Alaska..... 1935
— physiographic types 2007
Subordinate structures of Massanutten Mountain syncline in northern Virginia 1994
Subsurface structure of San Joaquin Valley, California 1957
— studies by petroleum geologists..... 1951
— study of Ellenberger formation in west Texas 1923
Sulfide-silicate immiscibility, Evidence of.. 2003
Sun-cracking, Columnar limestone produced by 1923
Superfamily Discosoroidea (Nautiloidea).... 1969
Surface of Newfoundland..... 1665
Survey of Alaskan weather..... 2020
SUTTON, A. H.: Time and stratigraphic terminology 1397
SWARTZ, C. K., and SWARTZ, F. M.: Silurian of central Appalachians..... 2008
SWARTZ, F. M., and SWARTZ, C. K.: Silurian of central Appalachians..... 2008
Syenite from Panamint Range..... 1961
Symbathocrinus, Growth stages of..... 1973
Syncline in northern Virginia, Subordinate structures of Massanutten Mountain.... 1994

Taconic disturbance and associated events.. 1932
TAFF, J. A., *et al.*: Type locality of Cretaceous Chico formation..... 1311
TALMAGE, S. B.: Logarithmic scale for rock diagrams 1950
Tarapacá, Chile, Nitrate deposits of..... 1941
Tarryall Range, Colorado, Ore-bearing pipes in 1923
Tarsus and locomotor methods of earlier tetrapods 1976
Tazewell County, Virginia, Stratigraphy in 1924
Tectonics of Northern Wallowa Mountains, Oregon 2015
Tejon formation, Grapevine Canyon, California, Eocene stellate orbitoidal Foraminifera from type..... 1984
Tektites, Distribution and origin of..... 1919
—, Moon as a source of..... 1936
Tennessee, Magnetic survey of Wells Creek Basin 1953
Terlingua-Solitario region, Texas, Igneous rocks of..... 1539
Terminology, Time and stratigraphic..... 1397
Terraces of Mississippi River, Pleistocene 2041
Terrestrial radioactivities, Measurement of 1927
Tertiary and Pleistocene sedimentation in relation to Pliocene-Pleistocene boundary in Great Plains..... 1934
— grasses and other herbs from High Plains 1969
— in Pacific Northwest, Geological history of 2035
— marine Mollusca, Check list of California 1972
— prairie, Trend of changes in Late..... 1925
— relationships in northern South America, Cretaceous- 1995
— stratigraphy and paleontology of south-central Washington and adjacent Oregon, Late 2018
— succession of life zones on southwest slope of Mount Diablo, Later..... 1985

Page

Tertiary-Cretaceous relationships in Coastal Plains area of Texas..... 2006
Tetrapods, Tarsus and locomotor methods of earlier 1976
Texas, "Bone pocket" in Lower Permian Luecers formation of Baylor County.... 1975
—, Concentric patterns in granites of Llano-Burnet region 971
—, Correlation of Early Paleozoic sections in 1921
—, Cretaceous - Tertiary relationships in Coastal Plains area of..... 2006
—, Igneous rocks of Terlingua-Solitario region 1539
—, New fossil localities in..... 1977
—, Pleistocene artifacts and associated fossils from Bee County..... 1627
—, — stone images from..... 1944
—, Source of beach sands on Gulf Coast of 1922
—, Stream terraces in..... 1952
—, Study of Ellenberger formation in..... 1923
— coastal region, Subsurface studies by petroleum geologists in..... 1951
— Cretaceous and paleoecological significance, Pyrite faunas of Washita and Eagle Ford groups of..... 1977
— fossil fishes 1971
— Gulf Coast, Exhibit of stratigraphy and structural forms of..... 1952
— — — as a classic region in study of sedimentation 1949
— — Coastal Plain, Pliocene Equidae of 1970
Theory, Seismologist's difficulties with mathematical 2039
THIEL, G. A., *et al.*: Studies of Lake Superior pre-Cambrian by accessory-mineral methods 1429
THIESMEYER, L. R.: Improved laboratory procedures: Introduction to minerals and rocks 2042
THOMPSON, H. D.: Topography of Monterey, Staunton, and Harrisonburg quadrangles 2009
Thrust faulting at southern end of Big Horn Mountains, Wyoming 1934
— faults in foothills of Alberta..... 1928
Thunder Lake, Ontario, Archean metaconcretions of 1841
Time and stratigraphic terminology..... 1397
Tin belt, Genetic history of pegmatites and associated rocks of Carolina..... 1999
TOMLINSON, W. H.: Triassic dikes of basaltic glass at Safe Harbor, Pennsylvania..... 2009
Tonopah, Nevada, Upper Miocene Equidae from San Antonio Mountains near..... 1983
Topography of Cape May formation, Marine 2002
— — Monterey, Staunton, and Harrisonburg quadrangles 2009
TOULMIN, LYMAN, JR.: Correlation of Lower Eocene formations of New Jersey and Alabama 2009
Treanorite, a new mineral from Crestmore, California 1965
TREASHER, R. C.: Distribution of historic earthquakes in Pacific Northwest..... 2034
—: Geology of Portland, Oregon, area..... 2034
Trend of changes in Late Tertiary prairie... 1925
Triassic dikes of basaltic glass at Safe Harbor, Pennsylvania 2009
— of Anson County, North Carolina..... 1920
— — New Jersey, Major faulting in..... 1994
— outlier in Pennsylvania, Spitzenberg conglomerate as a..... 2011
Trilobites of Nevada, Ordovician 1984
Trans-continental gravitational and magnetic profile of North America and its relation to geologic structure..... 1954
TUCK, RALPH: Origin of muck-silt deposits at Fairbanks, Alaska 1295
Tuff resembling vitrophyre and pitchstone.. 1957
Tungsten-bearing manganese deposit at Gelconda, Nevada 1359, 2026
Tuscaloosa formation of western Kentucky.. 1940

Page

TWENHOFEL, W. H.: Silurian strata of Aroostook County, Maine..... 1978
—, and MACCLINTOCK, PAUL: Surface of Newfoundland 1665
— —: Wisconsin glaciation of Newfoundland 1729
Twin Sisters Mountains, Washington, Ultrabasic rocks of 2019
Two new Pliocene formations in California.. 1956
TYLER, S. A., *et al.*: Studies of Lake Superior pre-Cambrian by accessory - mineral methods 1429
Tyosen (Korea), Relief regions of..... 2002
Type locality of Cretaceous Chico formation 1311
Types, Submarine physiographic..... 2007

ULRICH, E. O., *et al.*: Ozarkian and Canadian cephalopods: Part 1, Nautilicones..... 1979
Ultrabasic rocks of Twin Sisters Mountains, Washington 2019
United States, Correlation of structural elements-problems 1955
— —, Geology of phosphate deposits in..... 2040
Upper Cretaceous pelecypods of *Venericardia beaumonti* group from Iran..... 1976
— Helderberg-Oriskany relations in West Virginia 2012
— Miocene Equidae from San Antonio Mountains near Tonopah, Nevada..... 1983
— — fish from northern rim of Santa Monica Mountains, California..... 1982
URRY, W. D.: Radio-elements in water and sediments of ocean..... 2010
Utah, Glaciation in Wasatch Plateau..... 1173
Utilization of public lands in Alaska..... 2030

Validity of four additional classes of arcuate structures 1998
VAN VALKENBURG, S.: Course on geography of national defense 2010
Vapor and liquid phases in system CO_2-H_2O-K_2O-SiO_2, Equilibrium between 1035
Venericardia beaumonti group from Iran, Upper Cretaceous pelecypods of..... 1976
Venezuela, Pleistocene mollusks from Margarita Island 1975
VETTER, J. M.: Methods of geological subsurface studies by petroleum geologists in Texas-Louisiana coastal regions..... 1951
VINE, A. C., *et al.*: Geophysical investigations in emerged and submerged Atlantic Coastal Plain. Part IV. Cape May, New Jersey, section..... 1821
Virgin Islands, Geology and hydrology of Saint Croix 1992
— Spring area, Structural features of..... 1936
Virginia, Chazyan and Black River stratigraphy in Tazewell County 1924
—, Distribution of Petersburg granite in southeastern Piedmont 2004
—, Industrial limestones in 2039
—, Interpretation of cross section of Blue Ridge north of Balcony Falls..... 1990
—, Subordinate structures of Massanutten Mountain syncline in northern 1994
— Coastal Plain, Geology and hydrology of southeastern 1992
Vitrophyre, Tuff resembling..... 1957
VOKES, H. E.: Geological observations in Lebanon Mountains of eastern Asia..... 1951
"Volatile transfer" differentiation and connate waters, Gravity versus 2000
Volcanic problems in Southern Absaroka Mountains, Wyoming, Structural and... 1413
Volcanics, Specimen Mountain..... 1951
Volcanism in Hawaii, Four-phase 1947
— — Salt Lake City region, Epochs of..... 2031
VOSKUIL, W. H.: Problems of coal distribution and transportation in war time.. 2011

WAHLSTROM, E. E.: Audubon-Albion stock, Boulder County, Colorado..... 1789

Page

WAHLSTROM, E. E.: Hydrothermal deposits in Specimen Mountain volcanics, Colorado 1951
WALKER, FREDERICK: Differentiation of Palisade diabase 1059
Wallowa Mountains, Oregon, Tectonics of Northern 2015
War time, Problems of distribution and transportation of coal 2011
WARREN, W. C.: Relation of Plateau basalts of eastern Washington to certain andesitic rocks of Cascade Mountains.... 2034
Wasatch Plateau, Utah, Glaciation in.... 1173
Washington, Browns Point formation, Olympic Peninsula 2022
—, Distribution of igneous rock in Olympic Peninsula 2023
—, Eocene and Oligocene coral faunas of .. 1983
—, Geology of Okanogan Valley 2035
—, Glacial history of southeastern 2024
—, Origin of clastic dikes in Lewiston Basin 2027
—, Pleistocene history of Lewiston Basin .. 2027
—, Relation of andesitic rocks of Cascade Mountains to Plateau basalts of eastern 2034
—, Ultrabasic rocks of Twin Sisters Mountains 2019
— and adjacent Oregon, Late Tertiary stratigraphy and paleontology of southcentral 2018
— magnesite, Structural features of 2018
Washita and Eagle Ford groups of Texas Cretaceous and paleoecological significance, Pyrite faunas of 1977
Water and sediments of ocean, Radio-elements in 2010
WATERS, A. C.: Geology of Okanogan Valley, Washington 2035
Waters, Geochemical data on Saratoga mineral 2008
— in West Virginia, Origin and geochemistry of connate 1995
Weather, Survey of Alaskan 2020
Weathering, Crystallization of salt as a factor in rock. 1956
WEAVER, C. E.: Geological history of Tertiary in Pacific Northwest 2035
—: Mesozoic Andean geosyncline..... 1963
WEAVER, PAUL: Exhibit of stratigraphy and structural forms of Texas-Louisiana Gulf Coast 1952
WEEKS, A. W.: Stream terraces in Texas and their relation to formations of Gulf Coastal Plain 1952
WEIGLE, W. G.: Forests of Alaska 2036
Welded tuff resembling vitrophyre and pitchstone at Bare Mountain, Nevada.. 1957
Wells Creek Basin, Magnetic survey of 1953
WENTWORTH, C. K., and WINCHELL, HORACE: Koolau basalt series, Oahu, Hawaii 1953
West Coast, Evolution of genus *Astrodapsis* on 1981
— Virginia, Origin and geochemistry of connate waters in 1995

Page

West Virginia, Upper Helderberg-Oriskany relations in 2012
WHITCOMB, LAWRENCE: Spitzenberg conglomerate as a Triassic outlier in Pennsylvania 2011
WHITE, W. T.: Alaskan livestock resources and livestock problems 2036
WHITING, KEITH: General features of geology of Coeur D'Alene mining district, Idaho 2036
WHITTLESEY, DERWENT: Appropriate political control of nation's defense resources 2011
WIESE, J. H.: Study of Abrigo limestone ... 1964
Willamette Valley fill, Stratigraphic relations of 2016
WILLARD, BRADFORD: Martinsburg sequence in Lehigh County, Pennsylvania..... 2012
WILLIS, BAILEY: Mechanics of metamorphic orogeny 1964
WILLIS, ROBIN, *et al.*: Folded thrust faults in foothills of Alberta 1928
WILSON, C. W., Jr.: Magnetic survey of Wells Creek Basin, Tennessee 1953
WILSON, H. D. B., and HENDRY, N. W.: Geology and quicksilver deposits of Coso Hot Springs area 1965
WINCHELL, HORACE, and WENTWORTH, C. K.: Koolau basalt series, Oahu, Hawaii. .. 1953
Wind direction along southern shore of Lake Michigan 1947
— River Mountains, Recent recession of Dinwoody Glaciers 1924
Winnipesaukee region of New Hampshire, Igneous rocks of 2005
Wisconsin glaciation of Newfoundland 1729
WOODFORD, A. O., *et al*: Section across Commercial Quarry, Crestmore, California. 1965
— — —: Treanorite, a new mineral from Crestmore, California 1965
WOODWARD, H. P.: Upper Helderberg-Oriskany relations in West Virginia 2012
WOOLLARD, G. P.: Magnetic investigations in Atlantic Coastal Plain 2013
—: Trans-continental gravitational and magnetic profile of North America and its relation to geologic structure 1954
— *et al.*: Geophysical investigations in emerged and submerged Atlantic Coastal Plain. Part IV. Cape May, New Jersey, section 1821
World, Mapping the changing 1990
Wyoming. Recent recession of Dinwoody Glaciers 1924
—, Structural and volcanic problems in Southern Absaroka Mountains 1413
—, — types and trends 1930
—, Thrust faulting at southern end of Big Horn Mountains 1934

YOUNG, J. A., Jr.: Pennsylvanian Scaphopoda and Cephalopoda from New Mexico 1979